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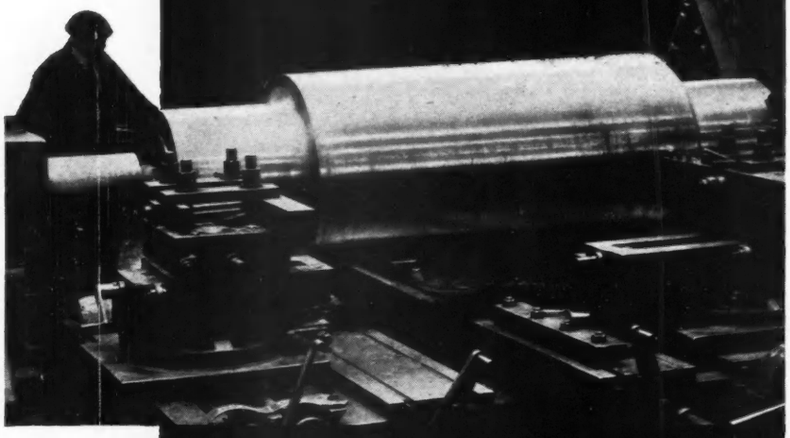

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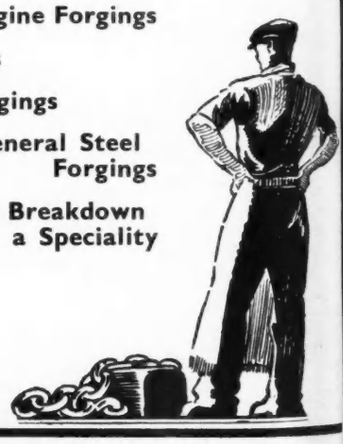

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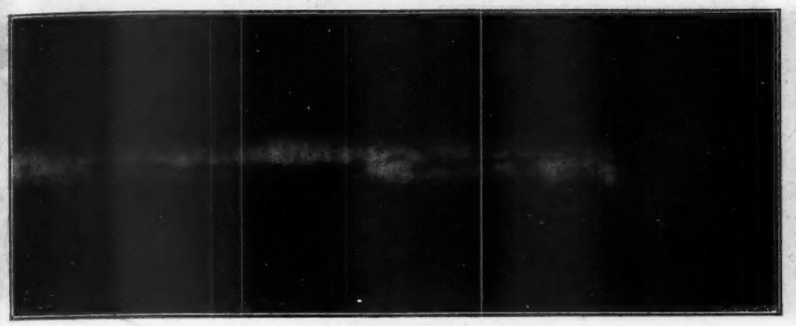


FIG. 3. AS WELDED.

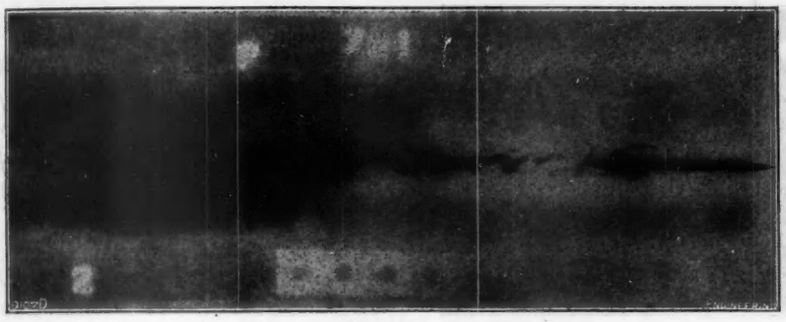


FIG. 4. REINFORCEMENT REMOVED.

STREET-LIGHTING DEMONSTRATION AT SOUTHPORT.

DURING the Annual Conference of the Association of Public Lighting Engineers, which took place at Southport on Monday, September 15, and the following days, ten installations of street lighting, based on the Ministry of Transport's final recommendations for Group A Roads, were demonstrated for comparison. Three of these demonstrations made use of 400-watt mercury-discharge lamps, one utilised 250-watt mercury lamp, three used 140-watt sodium lamps, and three employed tubular fluorescent lamps. With the exception of two, in which the lanterns were of radically different design from the conventional type of street lighting fittings and required special poles, all the installations relied on existing columns, previously tramway poles, for their spacing.

All the lanterns were noteworthy for the care taken in their mechanical as well as their optical and electrical design. Details that may be mentioned in this connection are the simple and robust methods of attaching the lanterns to the brackets without screwed couplings, thus permitting easy and rapid installation, as well as the arrangement for simple and quick opening for cleaning and relamping and the elimination of small screws and washers. Several makers had taken advantage of the experience gained in the use of light-weight weather-resistant alloys, not only to reduce the weight of their products, but to incorporate improvements in design. For the first time, tubular fluorescent lamps were to be seen at an official demonstration of the Association. Optically, these are very suitable for street lighting as their length enables excellent road coverage to be obtained, while their relatively low brightness reduces the glare factor. The design of the lanterns for these light sources has presented several problems, owing to their dimensions and the need to simplify the maintenance of equipment with large glazed panels. It is claimed, however, that in this respect solutions have been reached, their attainment having been facilitated by the long life (2,500 to 3,000 hours) of the lamps.

The fluorescent-lamp installations included eight lanterns in Nevill-street, Southport. These were erected by the British Thomson-Houston Company, Limited, Rugby, and each contained three 80-watt lamps. The length of these light sources and the disposition essential to obtain optimum distribution necessitates a lantern of larger size than is at present used. The mechanical design of these lanterns has received close attention and cleaning can be effected simply and quickly without removing the main Perspex cover. In fact, the cover has only to be removed at long intervals to clean the reflectors and the interior. The control gear and starter switches are built into the lantern, so that the equipment is simple to connect. The bottom lamp can be arranged on a separate switch, for lighting after midnight. The mounting height is 25 ft. and the spacing 120 ft. The seven lanterns erected in Hoghton-street by the General Electric Company, Limited, Magnet House, Kingsway, London, W.C.2, carried four 40-watt tubular fluorescent lamps. The lantern bodies are made entirely of non-ferrous materials and sheet Perspex is used for glazing.

The distribution may be described as axial asymmetric, the control of the light flux being effected by anodised aluminium reflectors. All the auxiliaries are accommodated in the body of the lantern, thus simplifying the column wiring. Access for relamping is obtained through glazed doors on each side. The lamps, which are mounted at a height of 25 ft., are carried on concrete columns spaced 110 ft. to 120 ft. apart. These columns were specially designed to carry the large lanterns. The third fluorescent lamp installation consisted of seven lanterns provided by the Revo Electric Company, Limited, Tipton, Staffordshire, which were erected in Kingsway and Coronation-walk. Each of these lanterns incorporated two 80-watt lamps and reflectors arranged to give asymmetric light distribution. The reflectors are of specular finish and the lantern construction is mainly of aluminium, which has been specially treated to resist corrosion. As in the other installations, the control gear is housed within the lantern, which is glazed with Perspex. Sliding lamp-holders are provided to facilitate replacement.

The installation of Metropolitan-Vickers Electrical Company, Limited, Trafford Park, Manchester 17, in Scarisbrick New-road consisted of eight fittings carrying 400-watt horizontal mercury lamps with magnetic arc deflectors. These were installed at a height of 20 ft., the average spacing of the columns being 120 ft. Non-axial asymmetric light distribution is obtained from a single-piece prismatic reflector bowl which is designed to utilise the largest possible amount of direct light from the lamp. An anodised aluminium reflector under the canopy deflects the remaining upward light flux on to the refractor prisms. In this way, it is claimed, the advantages of the enclosing refractor, as used with vertically-burning lamps, are combined with those peculiar to the horizontal source to produce a unit of high overall efficiency. The canopy is of cast-aluminium alloy, to which is hinged an easily removable retaining ring for the single-piece refractor bowl.

X-RAY EXAMINATION OF BUTT WELDS.*

By W. D. GARRICK.

THIS paper deals with the examination by X-rays of butt welds in pressure vessels. Although based on experience with welded drums for Yarrow-boiler installations, this summary is equally applicable to all forms of fusion-welded pressure vessels. For a number of years X-ray examination has been a fundamental requirement of every code governing the fabrication of fusion-welded pressure vessels. Accumulated experience in this important field has established that X-ray examination is the most successful form of non-destructive test and, further, the expense incurred is more than offset by the value of the information obtained.

The interpretation of weld radiographs depends not only on an understanding of the various characteristic images, but also on the processes by which the radiograph is produced. Such factors as density, definition, contrast and shape are affected by the technique employed. It is, therefore, possible to produce a uniformly clear radiograph from a faulty weld, while, on the other hand, the radiograph of a satisfactory weld may exhibit shadows suggesting internal flaws.

The theoretical principles involved in the use of X-rays are well-known and do not require to be dealt with here. X-ray tubes in general use range from 60 to 1,000 kV. With the latter it is possible to penetrate 8 in. of steel within an economic time. For work on pressure vessels, a semi-portable equipment is commonly used, as this type of set is easily transported to a position parallel with the work under examination. Fig. 1, opposite, illustrates a small pressure vessel under examination by a portable X-ray apparatus.

The X-ray beam forms an image on the photographic film by differential absorption, or, in other words, the beam will be absorbed to an extent depending on the homogeneity of the specimen under examination. A defect in the specimen permits more radiation to reach the film and so produces a darker image on development. When good technique is applied to the examination of butt welds, X-rays are capable of revealing defects of a magnitude down to 2 per cent. of the weld thickness. Good technique depends on the operator's control of a number of variables, which include the setting up of the equipment, the use of screens, tube voltage and current, the control of scatter and the processing of the film.

From Fig. 2, opposite, some of the fundamental geometric considerations involved in setting up the equipment can be observed. Control of definition depends on the focal spot size and the ratio of the tube-object and object-film distances. For practical reasons, the focal spot size must be finite, but should be a minimum to reduce the effect of penumbral shadows. Definition improves with an increase in tube-object distance and a decrease in object-film distance. In practice, with a focal spot size of 5 mm. square, the ratio of these two should be at least 19 to 1, while the tube-film distance should be about 36 in. As X-ray intensity varies as the reciprocal of the square of the distance from the tube, the time available for inspection may keep the fundamental ratio to a minimum.

Even with the modern double-coated film at present available, only a fraction of the total X-ray energy is absorbed by the film. Intensifying screens are used to reduce exposure time. These consist of two types, known as salt screens and metal screens. The salt screen is usually of calcium tungstate which fluoresces under the action of X-radiation and decreases the exposure time by a factor of about 40. Metal screens may be of tin or lead foil, and to some extent exclude the rays of longer wavelengths which otherwise blur the image. They have an intensifying factor of about 5. Due to spreading of light in the salt screens the definition is poorer than when using metal screens. In general, however, salt screens are favoured for this class of work, the definition being adequate and the exposure time reasonably short.

The selection of a suitable tube voltage for a given specimen is a compromise between the desire for a short exposure time and sufficient contrast on the radiograph to reveal small defects. To reduce exposure time the tube current should be as high as possible, but not so high as to risk the danger of an over-heated tube. When examining thick shells or vessels, it is necessary to prevent the scattered secondary radiation from reaching the film where it would create general fogginess. Cones attached to the tube or lead shielding of the weld are both effective in restricting the area under radiation. Such devices permit the X-ray beam to reach the film, while scattered secondary radiations arising from the metal not included in the examination is blocked out.

The sensitivity of radiographic technique is evaluated by means of a penetrameter. One type of this device is a $\frac{1}{4}$ in. strip of steel having the same composition

* Paper read before Section G of the British Association at Dundee on Tuesday, September 2, 1947.

X-RAY EXAMINATION OF BUTT WELDS.

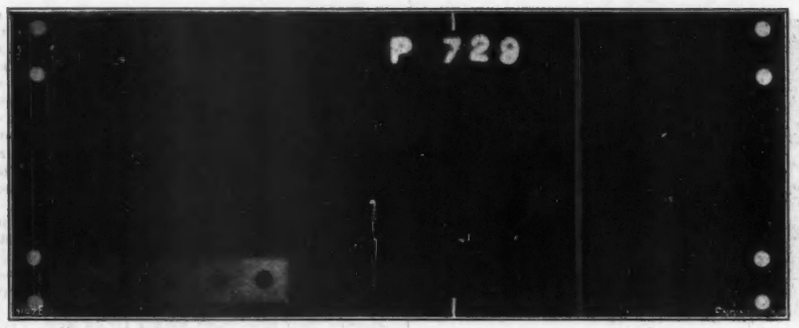


Fig. 5. Dark Shadows Due to Slag Inclusions.

Fig.6.

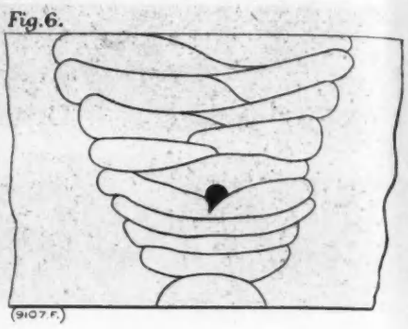
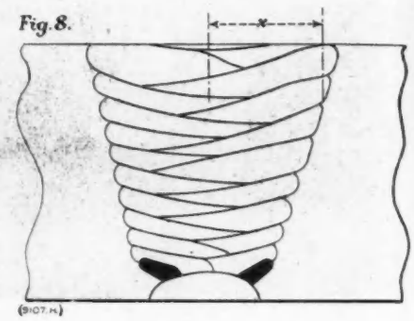


Fig. 7. Slag Lines in "U"-Type Welds.

Fig.8.



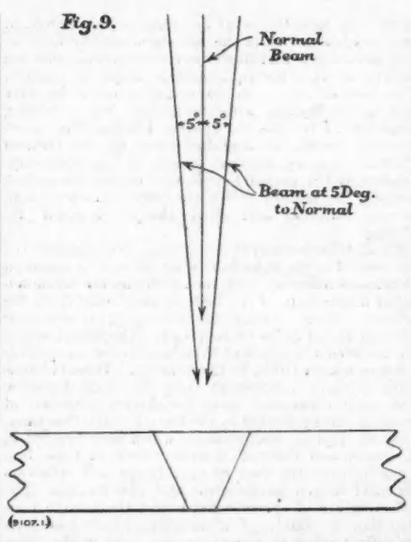
as the weld metal, and having five ¼ in. long steps of increasing thickness formed in the strip, with a $\frac{1}{16}$ in. diameter hole drilled in each step. The penetrameter is placed beside the weld during X-ray examination and on the film the depth of the thinnest step in which a hole can be observed is noted. This depth expressed as a percentage of the weld thickness is a measure of the sensitivity.

Modern X-ray films are coated with emulsion on both sides of the film base. They are processed in much the same way as normal photographic material, except that development is carried out to obtain maximum contrast. Care is required to preclude development marks which can complicate the interpretation of the radiograph. One of the practical considerations is the amount of weld that can be examined per exposure. It is assumed as self-evident that this should be as large as possible, provided there is no loss in efficiency. The limiting conditions are: the progressive increase in the thickness of material to be examined; and the progressive increase in the tube to film distance. It is found from reference to exposure curves for steel that an increase in thickness of 10 per cent. will result in a 30 per cent. reduction in density. Density is expressed as a value equal to $\log_{10}$ of the ratio incident light to transmitted light. If the normal working density is 1·2, a reduction of 30 per cent. would reduce this to 0·8, beyond which there would be an appreciable falling off in contrast. This variation in density becomes more pronounced when curved plates which are convex to the source of radiation, such as the circumferential seams of pressure vessels, are being examined. It can be said in general that a radiograph should not extend beyond the point where the metal thickness increases by more than 10 per cent.

In the welding of pressure vessels, it is essential that the surface of the weld should be ground smooth and level with the surface of the parent material. Fig. 3, page 405, demonstrates the effect if this is not carried out, while in Fig. 4, on the same page, the reinforcement has been removed, showing an increase in the sensitivity of fault detection and general appearance of the radiograph. The shadows appearing on a radiograph can be divided into three distinct groups: internal defects, surface defects, and processing defects. Subject to the limitations imposed by the standard of X-ray technique, internal defects of the following types can be revealed: gas inclusions, slag inclusions, lack of penetration, and cracks.

Gas inclusions are pockets of entrapped gas within the weld and consequently assume a rounded form. They vary from single small dark round shadows about

Fig.9.



$\frac{1}{32}$ in. in diameter, to groups of small spots. Occasionally a gas blowhole is located of considerably larger dimensions than the small porosity spots, and although it may exhibit a variation in density within its boundaries, it still retains the characteristic rounded form. With hand welding, these large blowholes are seldom encountered, the main gas defect being of the fine porosity type. This is usually a function of the electrode. Porosity in moderation is not serious, as generally there are no sharp edges which may tend to produce a crack or set up local stress concentrations.

In the interpretation of weld radiographs it is inadvisable to be too dogmatic regarding the shape of a defect shadow, for while, as stated, gas defects take up a rounded form this is not always the case, especially if the metal is chilled rapidly. This proviso also applies to slag inclusions which, as opposed to gas inclusions, are irregular in shape, usually exhibiting sharp corners as shown in Figs. 5 and 6, on this page. This angularity is more pronounced in the larger inclusions. In hand welding, the small inclusions may be slightly elongated as a result of being drawn out by the travel of the electrode. Fig. 6, it should be noted, shows a section of the weld taken through the plane indicated by the short white lines extending from the top and bottom edges of Fig. 5.

Slag also appears in the form of a broken or continuous line running parallel with the sides of the weld. Slag streaks appear singly or in pairs; in the latter case they are often termed "tramlines." The geometric properties of such defects often facilitate their location within the weld; for example, in Figs. 7 and 8, a slag line appears at a distance x from the centre of the weld. By referring to the weld section, it is evident that this slag line could only be located in the upper runs. In addition to the above variations in gas and slag inclusions there is a further difference in contrast of the shadow for defects of equal size. This is due to X-radiation being absorbed to a greater extent in the slag than in a gas pocket. The latter defect offers no appreciable resistance and, therefore, appears darker on the radiograph.

The third class of flaw, namely, lack of penetration, may occur either at the root or the sides of the weld, although there is a tendency to confine this term to the former position. Lack of side penetration in the weld is seldom shown on a radiograph, especially when the X-ray beam is normal to the weld surface. This type of fault usually constitutes a thin fissure-like cavity lying at an angle to the direction of radiation and so produces insufficient path difference to make any appreciable change in the density of the radiograph. Under favourable conditions, it may appear as a faint elongated cloud-like shadow, in which case the beam should be inclined at 5 deg. or 10 deg. to normal in the attempt to make the line of the beam coincide with the plane of the defect, as shown in Fig. 9. Owing to its very fine dimensions a defect of this nature rarely shows, and inclination of the beam seldom produces satisfactory results. On the other hand, lack of root penetration is easier to locate (Figs. 10 and 11, opposite), principally because it always occurs in the centre of the weld. In appearance it is a dark well-defined line shadow which may be broken or continuous.

The detection of cracks as shown in Figs. 12 and 13, opposite, provides the most difficult problem on X-ray examination and depends entirely on their orientation to the direction of radiation. When the crack lies along the beam the radiograph shows a dark wavy line, which may be continuous or bifurcated. When the plane of the crack is at an angle to the beam the shadow on the radiograph is broad and diffuse, and disappears altogether when the crack lies across the path of the X-rays. Cracks do not conform to any geometric principles, and the angle through which they are visible

X-RAY EXAMINATION OF BUTT WELDS.

FIG. 10. LACK OF ROOT PENETRATION IN DOUBLE-"V" WELD.

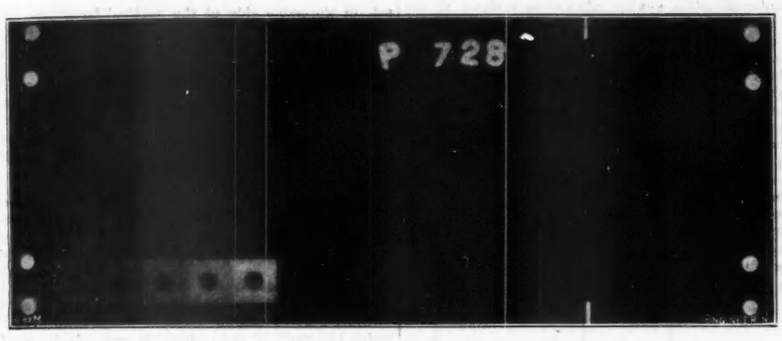


FIG 12. THIN DARK LINE INDICATING CRACK.

Fig. 11.

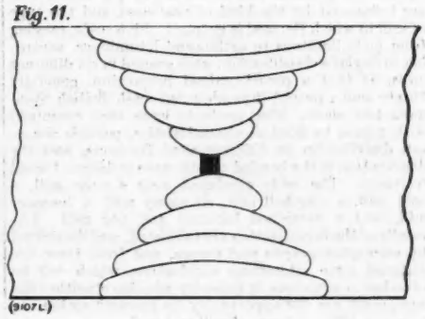
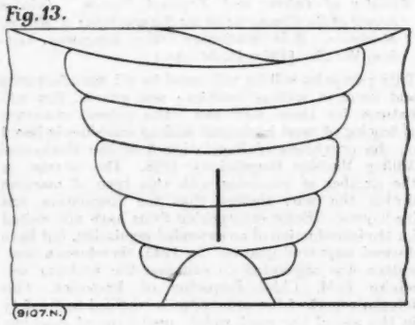


Fig. 13.



cannot be defined; also the angle at which the crack lies will generally vary from point to point, and only a part of the crack may appear in the radiograph in which it is first located. A searching examination must therefore follow to establish its limits, a series of radiographs being taken at different angles.

The technique involving angling of the X-ray beam may also be utilised to differentiate between lack of side penetration and slag existing at the side of the weld. In the first case, the defect shadow will almost certainly change its shape, while in the second, it is unlikely that any change will occur. Improper preparation of the weld for X-ray examination may produce shadows on the radiograph similar to those of internal defects. Surface pitting, grinding scratches and undercut may cause confusion. These are generally discernible by visual examination which should be made before commencing the interpretation. In any instance where the surface of the weld is not available for visual examination, a stereoscopic radiograph will indicate in what plane the marks occur. Excessive surface grinding causes a local decrease in the thickness of the material and produces a dark clouded radiograph. This will not confuse interpretation, but may obscure some internal flaws. Electrode spatter also gives rise to an unwanted shadow, but as spatter constitutes an increase in thickness, the shadow is lighter than the background density of the film.

As X-ray film, with its double-coated emulsion, is one of the most sensitive photographic materials, it requires extreme care in handling. While shadows caused by defective processing are not as a rule confused with those of internal defects they may render the interpretation more difficult, and reflect unfavourably on the standard of workmanship in the X-ray department. Processing defects refer to any shadows appearing in the film which are not due to either internal or surface defects on the weld. These include handling, storing, developing and drying. There are, however, two characteristics which greatly aid the identification of processing marks: the mark or shadow may appear remote from the region covered by the weld; and examination by reflected light will reveal if the mark exists on both emulsion layers. Only images built up by the radiation should appear on both sides of the film.

Probably the most common faults are pressure marks, scratches and drying marks. Pressure marks which are caused by bad handling or by the film being too rigidly held against the specimen under examination appear as dark diffuse shadows. Scratches might be confused with the characteristic image of a crack but for the fact that they only appear on one side of the film. Drying marks which result from drops of water remaining on a partly-dried film produce a slight variation in density and exhibit a dark line round their boundaries. Cracked screens, faulty film holders, old film and finger-prints, produce marks which are classed under the heading of defective processing.

Interpretation is seldom a simple matter. The illustrations of radiographs given in this paper showing defects have been specially prepared to illustrate in general terms the results of typical defects in the weld. In practice, the interpretation may be a complex problem involving a lengthy study of cause and effect. In many cases different types of defects may be closely associated in one region. The final result depends on the skill and experience with which the whole process of the examination and interpretation is undertaken by the staff of the X-ray department. Improved welding technique based on the results obtained by X-ray examination is now widely experienced. The necessity for cutting out and re-welding after X-ray examination only rarely occurs, and when re-welding is necessary it is only a small percentage of the total length of welded joint.

Another point is the correlation of defect shadows with their position in the weld. The divergence of the X-ray beam in some cases will project defect shadows out of their true position. Allowance should be made for this before repairs are carried out. Stereoscopic technique is used extensively in locating the depth of a flaw. Two exposures are made on one film from different directions, thus producing two defect shadows. Knowing the geometric conditions of the exposure and the separation of the shadows, the depth of the defect can be calculated.

In conclusion, X-ray examination is the most valuable non-destructive means of determining the quality of the all important butt weld. Given good technique and proper interpretation, the users can obtain not only a pictorial record but also the means whereby the actual welding can be improved to a degree commensurate with the importance of a pressure vessel.

THOMAS HAWKSLEY LECTURE.—The thirty-fourth Thomas Hawksley Lecture of the Institution of Mechanical Engineers, will be delivered at the Institution, Storey's-gate, St. James's Park, London, S.W.1, on Friday, November 21, at 5.30 p.m., by Sir Alwyn D. Crow, C.B.E., Sc.D., F.Inst.P. The lecture will be entitled "The Rocket as a Weapon of War in the British Forces." It is hoped that the lecture will be repeated at several of the Institution's local branches, at dates and places to be announced later.

NOTES ON NEW BOOKS.

Geological Structures and Maps. By A. ROBERTS, M.Sc., A.M.I.Min.E., A.M.I.C.E. Sir Isaac Pitman and Sons, Limited, Parker-street, London, W.C.2. [Price 12*s.* 6*d.* net.]

THIS new addition to Pitman's well-known "Engineering Degree Series" of text-books is a short introduction to the interpretation of geological maps. The first 27 pages are devoted to explanatory notes on the principal structural features of rock formations, and the author is to be commended for his skilful use of diagrams to illustrate the effects of folding and faulting of sedimentary strata; the excellent diagrammatic illustrations in this explanatory section greatly simplify the subject matter. The second section of the book consists of 39 maps, forming a graded series of exercises on plotting the outcrop positions of rock strata and the construction of vertical sections to show the underlying rock structures. Descriptive matter and exercises are carefully graded and correlated to form a systematic practical course in the interpretation of geological maps, and any student who reads the text diligently and works conscientiously through the exercises cannot fail to acquire an appreciable knowledge of the most important geological structures. Many will regret the omission of the answers to the exercises, however, and the author might consider the advisability of including all numerical answers in a subsequent edition, to provide a check on the work of the lone reader and to enable him to develop confidence in his work. In addition to students, mine surveyors and civil engineers who are concerned with problems requiring the use of geological maps will find this book an interesting and instructive introduction to the basic principles of structural geology.

Department of Scientific and Industrial Research. Fuel Research. Technical Paper No. 49. *The Characteristics of Pulverised Coal. Effect of Type of Mill and Kind of Coal.* H.M. Stationery Office, Kingsway, London, W.C.2. [Price 1*s.* 3*d.* net.]

THIS paper is a report of an investigation carried out by Mr. Robert Cook, M.Sc., under the supervision o Mr. T. F. Hurley, O.B.E., B.Sc., at the Fuel Research Station, Greenwich, of the Department of Scientific and Industrial Research. The work was completed before the outbreak of war in 1939, but publication was postponed on that account. Furthermore, it was not possible to include more than a summary of the findings in the volume of papers which were prepared for

discussion at the Harrogate Conference on Pulverised Fuel of the Institute of Fuel; but a complete accounnt is now available in the paper under review. The investigation was carried out to determine to what extent the physical characteristics of pulverised coal are influenced by the kind of coal used and the type of mill in which the coal is ground. Five coals, ranging from meta-lignitous to ortho-semi-bituminous, according to Seyler's classification, were ground in six different mills, so that a predetermined proportion, generally 80 per cent., passed through a 240-mesh British Standard test sieve. The products were then examined with regard to fineness characteristics, particle shape, ash distribution in different-sized fractions, and the distribution of the banded constituents in different-sized fractions. The mills employed were a tube mill, a ball mill, a ring-ball mill, an emery mill, a hammer mill, and a combined hammer and peg mill. The results of the investigation are tabulated, and illustrated by microphotographs and curves, and from these are deduced some interesting conclusions, which will be of value to engineers in industry who have neither the equipment nor the opportunity for research embracing so many different types of mill and coal.

Ministry of Labour and National Service. Interim Report of the Committee on the Safeguarding of Milling Machines. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 1*s.* 6*d.* net.]

This pamphlet will be welcomed by all manufacturers and users of milling machines and guards, jigs and fixtures for these machines. The present standard of fencing of most horizontal milling machines is based on the provisions of Regulation 3 of the Horizontal Milling Machine Regulations, 1928. The increase in the number of accidents with this type of machine during the war, showed that the Regulation was inadequate. Some enterprising firms have not waited for the introduction of an extended regulation, but have devised improved guards. In 1945, therefore, a committee was appointed to examine the problem and advise H.M. Chief Inspector of Factories. This interim report of the committee is confined to "safety in the use of the most widely used type of machine, including the fixed bed manufacturing type of miller, and the plain miller of the column and knee type." The report, which is well illustrated, will be of immediate practical value. The committee have dealt with fixed, automatic, and interlock guards, and such matters as jigs and fixtures, other related parts which are a source of danger, and the removal of swarf. Due attention is paid to minimising interference with production, by suitable design of guards, and in this connection the advantage of standardisation is stressed. A later report will deal with more specialised types of milling machines, but in the meantime, most users will find, in this pamphlet, a guide to some worth-while practical improvements.

Early Scottish Colliery Wagonways. By George Dott. St. Margaret's Technical Press, Limited, 33, Tothill-street, Westminster, London, S.W.1. [Price 2*s.* 6*d.*]

This pamphlet is a reprint of an article which appeared in *Colliery Engineering*. The author is a "mining man," and writes of the early colliery wagonways in the Fife and Lothian coalfields. He has recorded brief details of 24 lines which are worthy of inquiry, and deals at some length with ten of them. As a native of Musselburgh, Mr. Dott has been aided in his researches by local and family connections, and when writing about familiar districts, he avoids the prevalent error of presenting a thinly-disguised catalogue of references and quotations. Some fresh historical facts have been brought to light, as, indeed, it was the author's intention to supplement the work of the late Mr. C. F. Dendy Marshall. Three lines which are described in rather more detail than the others are the Tranent to Cockenzie line, laid with wooden rails in 1722, and the first railway in Scotland; the Fordell Railway, which survived until last year, and was the last private railway and harbour used in connection with the Scottish coal trade; and the Alloa Railway, an early wagon of which the author was fortunate in finding and photographing.

Plant for Domestic and Lighting Glassware.—Messrs. Chance Brothers, Limited, Glass Works, Smethwick, 40, near Birmingham, have installed a new automatic plant for the production of machine-made pressed and pressed and blown domestic and lighting glassware. The new furnace is now operating and is being used to manufacture goods primarily for the export market. The domestic glass which is being produced is intended to replace that previously imported from Belgium and Czechoslovakia, and it is expected that these British products will compete successfully with similar foreign types in export markets.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

ABSTRACTS OF SPECIFICATIONS RECENTLY PUBLISHED UNDER THE ACTS OF 1907 TO 1939.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, etc., of the Communicators are given in italics.

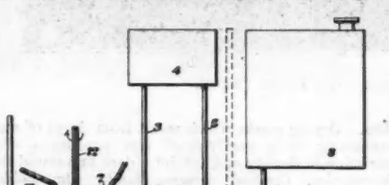
Copies of Specifications may be obtained at the Patent Office Sales Branch, 25, Southampton Buildings, Chancery-lane, London, W.C.2, price 1s. each.

The date of the advertisement of the acceptance of a Complete Specification is given after the abstract in each case, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

AERONAUTICS.

589,256. Engine Lubrication. P. J. Bateman, of South Farnborough, Hampshire. (2 *Figs.*) March 20, 1945.—This invention relates in particular to aircraft internal-combustion engine lubricating systems of the "dry sump" type, in which only a small portion of the total oil held in the system is circulated through the engine, and in which the loss from the small portion in circulation is made good from the large portion held in reserve. An engine oil sump 1 for collecting the oil from all the lubricated parts of an engine has a scavenge pump 2 arranged on its base so that the pump inlet is always covered with oil and suction losses are eliminated. This passes the oil from the sump 1 through a scavenge delivery pipe 3 to an oil cooler 4, through the cooler 4 and back to the sump 1 by a cooler-return pipe 5. A scavenge pressure regulating valve 6, to regulate the pressure to suit the cooler 4, is placed in the scavenge delivery pipe 3 and by-passes directly into the sump 1. A float-operated valve 7 is arranged in the sump, to



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control the flow of oil from the oil-supply tank 8 through a supply pipe 9 to the sump when the level in it drops as the oil is used up by the engine (not shown). The valve 7 connects the scavenge delivery pipe 3 to the supply pipe 9 so that the scavenge pump 2 may pass oil back to the oil-supply tank 8 if the level in the sump 1 rises. The oil-supply tank 8 is arranged behind a fire-proof bulkhead 10, in accordance with normal aircraft practice, and the supply pipe 9 from the tank 8 to the sump passes through it. The scavenge pump 2 and a pressure pump 11 are arranged to work in tandem and are driven by the same shaft 12. The pressure-pump inlet 13 is connected to the scavenge return pipe 5 close to its junction with the sump so that the pressure pump 11 can draw oil from the cooler 4 or from the sump 1. The pressure pump 11 passes oil to the engine lubricating system (not shown) by a delivery pipe 14 in which is arranged a pressure regulating valve 15 by-passing directly back to the sump 1. (*Accepted June 16, 1947.*)

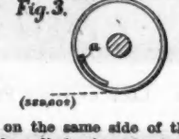
INTERNAL-COMBUSTION ENGINES

589,802. Valve Gear for Four-Stroke Engine. The National Gas and Oil Engine Company, Limited, of Ashton-under-Lyne, J. Smith, of Ashton-under-Lyne, and J. Jones, of Ashton-under-Lyne. (9 *Figs.*) July 11, 1944.—This invention relates to four-stroke cycle internal-combustion engines, and has for its main object the provision of valves and inlet and exhaust passages giving an improved swirl of the incoming air or mixture and a heat flow evenly distributed throughout the cylinder head. When applied to an engine having two cylinders in line, the valves are disposed in each cylinder head at the four corners of a square, the two exhaust valves E lying on one diagonal and the two inlet valves I lying on the other diagonal. Each inlet valve I is furnished with a rigid depending skirt forming a deflector or shroud *a*, each shroud forming part of a cylindrical surface the chord of which lies at an angle of about 60 deg. to the centre line of the inlet passage *b*. With this arrangement, tangential swirl, about the cylinder axis, of incoming fuel mixture or air is induced. The shrouds on the inlet valves of each cylinder may be disposed either at the sides of the inlet valves adjacent to the central transverse plane of the cylinder or at the sides, one of which is adjacent to and the other of which is remote from this plane. When shrouds are employed on the inlet valves they can be set at various positions as desired in order to produce varied swirls in the cylinder head; for example, they may be set approximately at right angles to the inlet passages and on opposite sides of the vertical transverse plane of the cylinder. Alternatively, they may be

Fig. 1.

Fig. 2.

Fig. 3.



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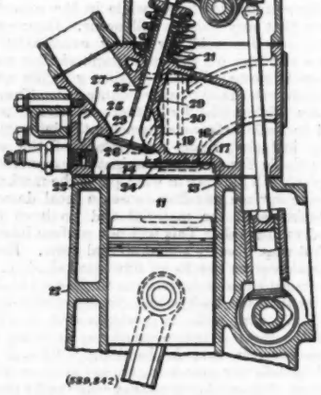
set on the same side of the vertical transverse plane of the cylinder, in order to promote swirl in a direction with the axis at right angles to the centre line of the crankshaft and the centre of the axis approximately midway between the piston crown and the cylinder head when the piston is at the top centre. Such shrouds can be employed in compression-ignition oil engines, petrol engines or in engines of the gas-ignition type where swirl is desirable for combustion. (*Accepted June 25, 1947.*)

589,842. Cylinder Heads and Valve Mechanism. Aston Martin, Limited, of Feltham, and C. Hill, of Feltham. (4 *Figs.*) March 23, 1945.—This invention is concerned with cylinder heads for multi-cylinder engines of the kind in which each combustion chamber is formed by a recess in the cylinder head, the roof of which slopes upward and outward from the cylinder bore so that the recess is wedge shaped, and in which one valve of the cylinder is seated in the sloping roof and the other valve in a part of the head over the cylinder bore. The objects of the invention are to give improved performance and to facilitate manufacture The cylinder block 12 has a head 13 which is formed with a shallow counter-bore 14 which forms a continuation of the bore of the cylinder 11. In the counter-bore 14 is arranged a valve seat 16 for an inlet valve 17, the axis of which is parallel to the axis of the counter-bore. The



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stem 19 of this valve has a guide 20 and two concentric compression springs 21, only one of which is shown. The roof of the counter-bore 14 has a recess 22 which is wedge-shaped in section and forms with the counter-bore the combustion chamber for the cylinder 11. The exhaust-valve seat 23 is on the roof of the recess and inclines downwards towards the axis of the counter-bore 14. The sloping roof of the recess 22 is of circular form and the walls of the recess are parallel to the cylinder axis. The recess overlaps the counter-bore 14 so that a step 24 is formed at their line of junction. The exhaust-valve seat 23 is thus raised above the level of the inlet-valve seat 16. The outlet duct 25 of the exhaust valve 26 rises steeply from the exhaust-valve seat 23, thus permitting a cooling jacket 27 to be arranged surrounding it, as well as the stem 28 and guide 29 of the exhaust valve. The inlet-valve seat 16 is of larger diameter than the exhaust-valve seat 23, and the former valve seat, when located as shown, provides for easy entrance of the combustible mixture. (*Sealed.*)

sible amounts, or "quanta," of energy. He showed, in fact, that, if the bound electrons, instead of radiating energy continuously, store up and finally release their energy in a single outburst when it attains some one of a certain series of values $h\nu$, $2h\nu$ . . ., then the predicted spectral distribution curve will agree with that found by experiment, provided that a suitable value be allotted to the constant factor h. The latter is the Planck "quantum of action," its value as given by Birge (1941) being $6{\cdot}6242 \times 10^{-27}$ erg. sec. It is a universal constant and one of the most fundamental of all physical constants. The value of h being known, the magnitude of the quantum of energy ϵ associated with radiation of frequency ν is given by the ideally simple relation $\epsilon = h\nu$. Planck assumed these energy quanta to be distributed at random among the individual oscillators. The probability that an oscillator shall possess a stated number of quanta will be smaller in proportion as ϵ is larger and, on this account, the higher-frequency oscillators will emit less energy than those of lower frequency, thus ensuring that E_λ shall tend to zero with λ. On the other hand, as the wavelength increases, the oscillators concerned will, on the average, emit more quanta; but their individual energy content becomes progressively smaller, thus ensuring that, as λ tends to infinity, E_λ shall again tend to zero in conformity with the observed trend of the spectral distribution curve. Moreover, in the course of the theoretical derivation of his formula, Planck obtained expressions for the first and second of his radiation constants in the form $C_1 = h c^2$ and $C_2 = \frac{hc}{k}$. Thus knowing c, the velocity of light, the numerical value of h can be calculated when C_1 is determined and, having determined C_2, a value for Boltzmann's constant k can be deduced; this value proved to be in good agreement with other independent estimates.

Impressive as such confirmatory evidence was, the idea of a bound electron that can oscillate without necessarily radiating and which, when it does radiate, is constrained to disburse energy only in definite units and not in arbitrary amounts, was so completely at variance with classical tradition as to constitute a potential menace to it. This central core of Planck's argument was, in fact, vigorously assailed by the older and more conservative physicists. Yet the fact that it had proved indispensable in enabling Planck to arrive at a quantitative solution of the formidable problem of the energy distribution in the black-body spectrum made a deep impression upon the younger and more progressive physicists. A sketch of what the quantum hypothesis has helped to achieve since it was first formulated by Planck provides the best proof of its significance.

Prominent among those who developed and extended Planck's ideas was Einstein. Whereas Planck had asserted, in 1900, that bound electrons emit and absorb energy in fixed finite amounts, subsequently, in 1911, he modified his contention by applying it exclusively to emission, leaving absorption to occur continuously. Einstein, in 1905, went even farther than Planck had originally gone, by advancing the idea that radiation, when propagated through a medium, possesses a quantum-like structure. These fixed finite quantities of radiant energy, or photons, retain their identity in the course of their transit from the moment of their emission to the moment of their absorption. The first signal success of this suggestion was in the theoretical interpretation it afforded of the observed facts of photo-electric emission, that is, the ejection of electrons from the surface of a metal when radiation falls upon it. Provided that the frequency of the incident radiation exceeds a certain critical or threshold value, these electrons emerge with kinetic energies up to and including a certain maximum value $E_{max.}$. This, in itself, would appear to offer no obstacle to a classical interpretation. The explanation of the observed dependence of $E_{max.}$ on the intensity and frequency of the incident radiation does, however, present insuperable difficulties to such an interpretation; for $E_{max.}$ is found to be independent of the intensity, while the relation between $E_{max.}$ and ν is the simplest of all relations apart from direct proportionality, for it is $E_{max.} = h\nu - E_0$, where E_0 is a constant for a particular surface and represents the work required to detach an electron from its parent atom, supposed to be located in the metal surface. According to Einstein, the atom can only absorb a complete photon and, if ν is the frequency of the incident monochromatic radiation, the energy transferred to the electron will be $h\nu$. Accordingly, if $h\nu > E_0$ and the atom is in the surface, so that E_0 is the minimum energy required to get the electron through the surface, the remaining energy $(h\nu - E_0)$ will appear as kinetic energy in the emerging electron and will assume its maximum value $E_{max.}$ Millikan, in 1916, carried out an elaborate test of this relation, using the alkali metals, and verified it completely. The value of Planck's constant h was found to be the same for all the metals employed.

The process just outlined is reversible, as in the generation of X radiation by the impact of fast-moving electrons on a metal target and, as experiments by Duane and Hunt confirmed, this inverse photo-electric effect is likewise governed by a quantum relation. Einstein, in 1907, also showed that quantum considerations are essential to account quantitatively for the observed temperature variation of the atomic heats of solids. Further confirmatory evidence came from the heat theory advanced by Nernst, for, as was shown by Sackur and Tetrode, the chemical constant introduced by Nernst independently of the quantum theory depends, in fact, on the quantum of action.

The most spectacular success of the quantum theory has been its application to line spectra. To account for line spectra, Niels Bohr (1913) advanced two hypotheses: first, that the atoms of a radiating gas can exist in certain discrete non-radiating stationary states, and, secondly, that an atom may pass from one to another stationary state of less energy and, in such a transition, monochromatic radiation of frequency ν is emitted subject to the frequency condition $h\nu = E_i - E_f$, where E_i and E_f denote the energies of the atom in the initial and final states, respectively, and h is Planck's constant. These hypotheses were applied to the Rutherford nuclear atom model, in which the electrons circulate in closed orbits under the action of the nuclear charge, as in classical planetary theory. Bohr's hybrid of classical and quantum theories, though strikingly effective in dealing with the normal hydrogen atom and the ionised helium atom, encountered difficulties when applied to atoms of higher atomic number. That this line of approach could be extended to X-ray as well as to optical spectra was confirmed by Moseley. A further extension of these ideas led Sommerfeld to a theory of the fine structure of spectral lines and the band spectra of molecules.

Another important property of radiation is that it is capable of exerting a pressure. Imagine a train of plane waves incident normally on a plane surface capable of absorbing them completely. If I is the amount of energy thus absorbed per unit area in unit time, the pressure exerted by the radiation on the surface, according to the classical electromagnetic theory, will be $\frac{I}{c}$, where c is the velocity of light. If the incident radiation is monochromatic and of frequency ν, the energy I transported to unit area of the surface in unit time by $\frac{I}{h\nu}$ of the photons also conveys momentum, of amount $\frac{I}{c}$. If we imagine the momentum shared equally among the photons, as is the energy, then each will be endowed with an energy $h\nu$ and a momentum $\frac{h\nu}{c}$. This idea was applied by A. H. Compton (1923) in discussing encounters between photons and sensibly free electrons. In what is termed the Compton effect, the energy and momentum of the photon are partly conferred upon the electron, the residues of each going to form a new photon of lesser energy and of lesser and differently directed momentum, hence lower in frequency and deflected obliquely from the direction in which the original photon was travelling. In such a process, the photon behaves effectively as a material particle. On the other hand, in the electron-diffraction experiments of Davisson and Germer, and G. P. Thomson (1927), the electron behaves as a "wave packet" rather than a material particle. In fact, de Broglie (1924) showed that, associated with a particle of rest mass m_0, there is a wave motion of which the wavelength is given by $\lambda = \frac{h}{m_0 v}$; so that, to an electron acquiring a velocity $v = 5{\cdot}9 \times 10^8$ cm. per sec. by falling through a potential of 100 volts, will correspond a wavelength of $1{\cdot}24 \times 10^{-8}$ cm. Such evidence implies the necessity of a dual concept of the electron as a particle and a wave.

The latest theoretical developments in atomic physics are associated with the names of Schrödinger and Heisenberg. Schrödinger generalised de Broglie's ideas and, in his wave mechanics, viewed the velocity of matter as a group velocity in certain waves underlying both matter and radiation. It is now recognised that all that can be determined by solving a problem in atom mechanics is the probability of an individual event. Schrödinger's procedure enables certain characteristic values to be calculated and these turn out to be precisely the values of the energy levels obtained (when this proves possible) on Bohr's theory. The definite orbits on the Bohr theory are replaced, however, by certain regions in the neighbourhood of the nucleus, where the probability of finding an electron is greater than for other regions. An important advantage of the newer methods is that the problem of atoms containing two or more electrons is not inherently intractable. Heisenberg abandoned all features of a physical model which are not directly observable (such as orbits) and confined his attention to directly measurable magnitudes (such as frequencies of spectral lines). He discovered that, in respect of emission and absorption of energy, atoms and molecules behave like systems of vibrations which conform to the rules of matrix algebra. Though, symbolically, Heisenberg's matrices appear remote from Schrödinger's wave functions, the two methods are mathematically equivalent.

The essentially statistical character of physical laws was underlined by Heisenberg in his uncertainty principle (1927), which states that the uncertainties Δq and Δp attaching to the simultaneous determination of two canonically conjugate variables (*e.g.*, position and momentum) are so related that $\Delta q \,.\, \Delta p \sim h$, in which the ubiquitous constant of Planck again appears. Though this has been held, in some quarters, to invalidate the principle of causality, Planck himself was not prepared to accept this, suggesting instead that "we might alter the formulation of the causal principle as we have received it from classical physics so that it may again have its strict validity."

Such are, in bare outline, some of the chief consequences that have followed from Planck's quantum hypothesis, none of which would have been possible without it. Planck's own realisation of the power of a hypothesis is best expressed in his statement that "an observer who does not allow himself to be led in his work by any hypothesis renounces beforehand all deeper understanding of his own results." The complete break with the classical outlook that Planck initiated gave an enormous impetus to physics and one that is far from exhausted. If the worth of a new concept in physics is to be judged not merely by its more immediately obvious implications, but also by its less immediately obvious ramifications, the quantum concept assuredly ranks among the most important in the whole of physics, holding, as it does, the key to all energy transactions between matter and radiation on the atomic scale.

ELECTRIC TRACTION EQUIPMENT FOR HOLLAND.—Metropolitan-Vickers Electrical Company, Limited, Trafford Park, Manchester, 17, have received a contract for the supply of traction motors, gears and pantographs for the high-speed motor-coach stock of the Netherlands Railways. The motors are connected permanently in pairs in series, and are insulated for 1,500 volts, although the terminal voltage is only 675. They are designed to accommodate axle bearings of either the sleeve or roller type. The gears are of the resilient type, the rims on the wheels having inwardly projecting lugs which house rubber units. The current collectors are single-shoe pantographs, the shoes being supported by a spring-and-link system so that some vertical movement is possible independently of the main structure.

SOME ASPECTS OF INSTRUMENTATION.*

By D. C. Gall.

The means available for making electrical measurements are surprisingly slender, because the only two quantities which give any direct indication of their presence are the electromagnetic field and the dielectric field. The phenomenon of measurement must therefore be made to affect one or other of these. Neither current or voltage can be directly measured. All that can be done is to measure the mechanical force exerted by a magnetic field or the force exerted by a dielectric field and infer the so-called current and voltage from them. In fact, the electromagnetic effect is the only usable way of detecting an electric current. In a few special cases the electrochemical effect of a current can be employed, but even so, it becomes necessary to weigh the deposit and thus to measure a mechanical force. If the heating effect is considered it will be clear that this is an energy, not a current, measurement; and requires further and rather complex means to measure it. The only way in which voltage can be detected is by using the electric field it produces. It is really rather astonishing that, out of such minute forces, the endless range of measurements and the extremely high precision now obtained is possible.

In this connection it is of interest to consider the relation between the energy used in a measuring system and the accuracy of that measurement. Resistance is often the value employed in measuring a wide range of physical phenomena. If a resistance change of 1 per cent. is made, the change in the power available in the detector circuit will depend upon the type of measuring system employed. The choice of this system will depend upon the accuracy of measurement required. If, for example, resistance change is measured by the voltage drop under optimum conditions, the ratio between the power dissipated in the system and that available for the measurement will be 200 to 1. If the same measurement is made by a Wheatstone bridge, the power ratio will increase to 600,000 to 1, and if a Kelvin double bridge is used, to at least 960,000 to 1, or more probably 20,000,000 to 1. These ratios are characteristic of any measuring system in which the precision is increased by some form of electrical circuit balance. The efficiency becomes lower as the precision is increased. Since there is a practical limit to the amount of energy which can be dissipated in the measuring system, because of self-heating and other effects, accurate measurement requires a very sensitive detector of a small voltage. This is one of the greatest needs in electrical measurements.

The increasing importance of sensitive detection was clearly shown at the recent Convention on Automatic Regulators and Servo Mechanisms. For accurate control, immediate response to small stimuli and to the integral of these stimuli is required. It is also essential that there should be response to the rate of change and that the detector should have a very high degree of amplification, so that sufficient power may be available to operate robust indicators and relays. The use of amplification in measuring phenomena by electrical means can be regarded as one of the milestones in the technique. The ideal amplifier would have very high sensitivity; stand much mechanical and electrical abuse; work in any environment without maintenance or adjustment; and give linear and instant response to the smallest of inputs without zero drift or background noise. A great deal of work has been done in this field with some success, but the final system has not yet been evolved. There are special problems in applying valve amplification to industrial purposes. Many of the electrical effects which have to be measured are small electromotive forces, such as those from a thermocouple. The valve amplifier with high negative feed-back might seem to be adequate for such a purpose, but there are many difficulties in the way. Although negative feed-back will improve linearity between output and input it cannot eliminate internal background noise or zero drift. Many methods have been devised, such as chopping the input and amplifying it as an alternating current and finally rectifying it, but this involves continuously moving parts. The magnetic amplifier without any valves has many attractions for the engineer, because it appears to be as robust as a transformer and is free from maintenance problems. It has, however, limited sensitivity, time-lag and zero drift. The galvanometer and photo-cell amplifier has a very stable zero and little background noise. The galvanometer, however, is too delicate an instrument for many purposes, and yet what is required is an amplifier with the sensitivity of a good galvanometer. A good galvanometer will give a usable indication with 10^{-16} watt. This indication can be amplified almost without limit. To equal this sensitivity, a very-high-gain valve amplifier is required, the background noise and zero drift of which would be negligible. As a detector of small voltages the galvanometer is therefore still the simplest device. It cannot but be thought that the electrons which flow round its coil under the minute accelerating voltage and produce the magnetic field, which deflects the delicate coil, thus converting electrical into mechanical energy, might be used in an electronic system with greater advantage. It may not be beyond the ingenuity of the physicist, however, to devise a method of using these electrons to influence a larger number without mechanical conversion and to produce a detector of more robust design: an electromagnetic electron multiplier, perhaps.

Although the stock in trade of measuring devices is not very large, the variety of their application is legion. Some of the measuring devices have, as it were, direct access to the electrons while in others it is less direct. Of the former, the most widely used devices are the thermocouple, the photo-cell, and the piezo-electric crystal. These simplify the measurement of temperature, radiation, heat flow, pressure, and chemical analysis, and have many other applications. Next come those devices which change their circuit constants, such as the non-linear resistor, the rectifier and the magnetic alloy, each of which is affected in various ways by different physical phenomena. Simpler, but no less important, are the electromagnetic generator, such as the coil and magnet, the pure-metal resistance thermometer, and resistances, capacitances or inductances varied by displacements. Electrical methods of measuring magnetic effects constitute a major field of interest. Direct access to the electronic disturbance produced by a magnetic field without the need for movement of the conductor would be most useful in measuring devices. An improved form of the old and rather discredited bismuth spiral, which changes its resistance in a magnetic field, would be most useful, if it were fast, sensitive and stable. Mumetal wire exhibits similar effects, but is almost as difficult to use. A magneto-electric cell may not be beyond the physicists' ingenuity to produce.

Many electrical instruments depend on Ohm's law, which, like most physical laws, is an hypothesis to which only an approximation can be made in practice. Experimentally, no circuit obeys Ohm's law until various corrections have been applied. Even the best standard resistance has to be corrected for temperature and self-heating. Often the best instrument is one in which the errors due to imperfections have been most satisfactorily compensated. The design of an accurate instrument very largely depends upon the cancellation of the imperfections of the theory upon which it is supposed to work. In the ironless dynamometer wattmeter compensation for eddy currents in the current coils may be necessary with large currents, and, alternatively, compensation for self-capacitance with small currents. These conflict, so that very often there is no complete compensation for all conditions. In effect, the magnetic purity of the ironless coil is analogous to the rigid application of Ohm's law to a resistance. In many cases the changes brought about by external effects, which are a defect from one point of view, can be utilised to measure those very effects, thereby leading to useful applications. The change of resistance of a coil with temperature is the basis of the resistance thermometer. A similar change in any of the components of a circuit with strain or humidity, is the basis of a strain gauge or a moisture meter.

In the electrical-engineering field of measurement electronic methods have made many difficult things easy. The stabilisation of testing circuits is one of the outstanding advances. The tedium of attempting accurate calibration under unsteady conditions is now largely unnecessary. Circuits can be adjusted to some exact value of voltage, current or power, and will remain at these values to a very high order of steadiness. The value of this to the meter engineer is very great. This, too, is a branch of automatic control, and the theory underlying the design follows the same general principles as a sensitive detector for the errors, a very high and rapid amplification to correct the deviations with the rate of change, and the integral of the error added to the correction in due proportion. A whole field of new measurements which can be made only by electrical means has developed in physico-chemical analysis. The measurement of the absorption of radiation of various wavelengths from ultra-violet to millimetre waves has become of great importance in metallurgy, oil refinery, chemical manufacture, food processing and medical research. Here, again, the essential requirements centre round the amplification of small electromotice forces from bolometers, thermocouples or lead-sulphide cells. It is evident, in fact, that electrical measurements are extending into all branches of physics and industry, and that the electrical engineer, having solved most of his own problems, is now helping to solve the problems of others.

* Chairman's address to the Measurements Section of the Institution of Electrical Engineers, delivered on Friday, October 17. Abridged.

FEATHERING-BLADE WATER TURBINE WITH HYDRO-BRAKE.

The water turbine runner illustrated on page 396 embodies a simple but ingenious method of feathering the blades and is also fitted with a set of braking blades to prevent dangerous overspeed running. The blade-feathering gear and the hydro-brake gear have been developed by The English Electric Company, Limited, Queen's House, Kingsway, London, W.C.2. A general view of a runner so equipped is given in Fig. 1, in which the runner is shown with its blades in the normal running position and the braking blades, above the runner blades, extended to give their full braking effect. The photograph from which Fig. 1 has been reproduced was taken in the Liffey power station of the Electricity Supply Board, Dublin, as was also that reproduced in Fig. 4, which shows the feathering blades in the normal running position but the braking blades closed in and out of action. The fully-closed position of the feathering blades is illustrated in Fig. 5, in which the runner is shown without the hydro-brake. This condition is referred to in order to make it clear that the English Electric feathering mechanism is self-contained and wholly independent of the anti-racing brake. The feathering is controlled by an external governor, generally as fitted to other designs of feathering mechanism, but the hydro-brake is entirely automatic in action, functioning only when the runner speed exceeds a certain pre-determined limit.

Dealing with the feathering mechanism first, its arrangement is clearly shown in Figs. 2 and 3, but it may be pointed out that the photograph from which Fig. 3 has been reproduced was taken from a working demonstration model in which part of the hub cover has been cut away to expose essential parts of the feathering mechanism. Referring to Fig. 2, two blades are indicated at *a* with their operating levers at *b*. Each blade and its lever is cast in one piece, either in steel or stainless steel, a method of construction in which the advantages in eliminating connections between the two parts are obvious. The runner hub is lettered *c* and the hub cover, which is made in three parts, is indicated by *d*. Firmly secured to the hub is the sleeve *e*, to the bottom of which is attached a piston *f*. This piston is, therefore, stationary and the cylinder *g*, in which it is contained, slides on the sleeve *e*, the piston and cylinder constituting the oil-operated servomotor. The external form of the upper part of the cylinder is polygonal, the number of sides of the polygon depending on the number of blades in the runner. Cut diagonally in each face of the polygon is a groove of approximately T-section, lettered *h* in Fig. 2, and conspicuous in Fig. 3, in which grooves is a slide of phosphor bronze carrying a pin passing through the end of the lever *b*. The nuts on the ends of the pins can be seen in Fig. 3, and it will be apparent that the pins describe an arc as the blades are feathered. The vertical movement of the servomotor cylinder thus sets up a torque on the blade shaft which deflects the blade into the required pitch position. The tendency for the cylinder to turn round its axis, owing to the reaction between the lever slides and the slots, is countered by a pair of radiating wings which slide in ways formed in the hub cover. The wings and guide ways are clearly visible in both Fig. 2 and Fig. 3.

Oil under pressure is admitted above the piston through a passage in the sleeve *e*, forming a continuation of a central hole in the runner shaft, indicated at *i* in Fig. 2; the oil pressure causes the servomotor cylinder to move upwards. To effect the downward movement of the cylinder, pressure oil is admitted, through the space between the tubes *j* and *k*, the "exhaust" oil at each movement, of course, being returned through the passage by which it entered. The pressure oil is supplied by a pump on the turbine-operating platform, and is controlled either by the governor valves or manually, according to circumstances. The inner tube *k*, it will be seen, admits oil to the whole space inside the hub, so that the blade shaft bearings, the lever slides, and the cylinder guides are all continuously lubricated. The tube *k*, being attached at its lower end to the servomotor cylinder cover, moves up and down with the cylinder. The Tube projects above the end of the generator shaft, and the exposed part of it, between the shaft end and the flexible supply connection, is graduated so that it forms, in relation to the fixed end of tube *j*, an indicator to show the exact angle to which the blades are feathered. The hub *c* is split horizontally along the centre line of the blade shafts, this construction being necessary owing to the integral nature of the blade and its lever. The junction between the two parts is metal-to-metal, although there is a thin film of a jointing substance. The mating surfaces are scraped and spigoted, the two parts being held together by studs; both spigot and studs can be seen on the right of Fig. 2. The joint obtained is stated to be wholly satisfactory while, with regard to the sealing of the blade shafts, it will be noted that these are formed with a collar at the root of the

blade. Against this collar is carefully lapped a sealing ring of oil-resistant material, made in halves and held against the collar by a circumferential garter-spring. The sealing ring is held axially against the hub body by a solid L-section ring, and outside this assembly is a cover to fair off the hub, the last two parts being secured to the hub by set-pins. The outer shaft bearing is formed with a flange which bears against a matching surface on the lever boss. These two surfaces form a bearing to resist the centrifugal force on the blades. The inner bearing is in the form of a plain bush. Oil passages are drilled in the blade shaft, as shown on the left of Fig. 2 for the lubrication of the bearings.

Probably the most obvious advantage of the English Electric feathering mechanism is that, by fitting this mechanism below the plane of the blades, the "overhung" distance between the guide bearing *l* and that plane is kept very small when there is no hydro-brake; even with the provision of the hydro-brake, as in Fig. 2, the overhang is by no means excessive. The low position of the mechanism in the hub has the additional advantage that the feathering levers can be kept long, so that a smaller diameter of servomotor cylinder can be used than with other arrangements. It will be clear, moreover, that the mechanism can be inspected or renewed without removing the runner. The first step in this operation is to drain the chamber in the hub cover, and for this purpose a cock is provided in the nose-piece of the cover. For minor inspections, this nose-piece can be removed. For the renewal of, say, the servomotor piston rings, the hub cover is separated at the joint *m* when the servomotor cylinder cover and the piston can be removed. If the lever slides require attention the hub cover is removed from the joint *n*. All these operations can be performed from inside the draft tube with the turbine runner suspended in its usual position. Alternatively, the hub cover and nose-piece can be lowered as a whole from joint *n*. On re-assembling the parts, the oil previously withdrawn can be pumped back into the hub cover through the drain cock.

The hydro-brake, for preventing excessive speeds, may now be referred to. This gear comprises a ring *o*, Fig. 2, inserted between the top of the hub and the bottom of the structure housing the guide bearing, and fitted with a number of scoop-shaped blades *p* hinged at the bottom and folding back when not in action into diagonal slots in the ring *o*. The blades are shown in this withdrawn position by full lines in Fig. 2, and in their extended or working position by chain-dotted lines. The contour of the braking blades can be seen in Fig. 1, and it will be evident that their helix angle is contrary to that of the runner blades. The hydro-brake is designed to come into action when the speed of the turbine rises to between 50 per cent. and 60 per cent. above the normal running speed.

From experiments made with a turbine fitted with the hydro-brake, it has been shown that a runner having an optimum speed, as regards efficiency, of 190 r.p.m., had a maximum runaway speed, with the braking blades in use, of 266 r.p.m., that is, 40 per cent. greater than the optimum speed. On the other hand, when the braking blades were out of action, the maximum runaway speed was 478 r.p.m., that is, over 2·5 times the optimum speed. Application of the braking action is entirely automatic and depends solely on an excessive increase of runner speed being, therefore, quite independent of the normal automatic governor. The mechanism is very simple. The hinged braking blades are retained in the closed position either by springs in tension or by shearing pins, according to circumstances, the restraining action of springs or shear pins being eliminated when, owing to increase of speed above the predetermined limits, the centrifugal force tending to open the blades becomes greater than the restraining force. The braking blades are made of rustproof material, such as phosphor-bronze, and the hinge pins are of stainless steel. All contact faces are rustproof and thoroughly lubricated, and it will be seen from Fig. 4, which shows a runner that has been in service, how closely the blades fit into the retaining recesses of the hub. The springs or shear pins are tested during manufacture for release at the correct speed, while it is a simple matter to test them at any time in service seeing that the brake-releasing speed never approaches dangerous limits.

THE CONSTITUTIONAL RESEARCH ASSOCIATION.—A luncheon has been arranged by the Constitutional Research Association, to be held on Thursday, October 30, at 12.30 for 1 p.m., at Brown's Hotel, Albemarle-street, London, W.1, when Professor Frederick Soddy, F.R.S., Nobel Laureate for 1921, will deliver an address entitled "An Independent Scientist's Views on the Economic and Political Possibilities of Atomic Energy for the Future." Full information about the luncheon and the work of the Association are obtainable from the honorary secretary, Major Harry Edmonds, 32, Shaftesbury-avenue, London, W.1.

TEMPERATURE INDICATOR FOR ALTERNATOR ROTORS.

THE risk of rotor failure introduced by the practice of running alternators at full load interspersed with periods of complete shut down, was discussed by Messrs. R. H. Coates and B. C. Pyle in a paper read before the Institution of Electrical Engineers in December, 1945.* Therein it was pointed out that the source of the trouble was a shortening of the copper turns during service, and that the cure was to be found in narrowing the temperature range over which the rotor operated. A natural corollary to this diagnosis is the provision of means for continuously indicating the rotor temperature, in order to ensure that the maximum permissible value is not exceeded. To do this, however, is not altogether easy, and a solution which has been devised by Messrs. Metropolitan-Vickers Electrical Company, Limited, Trafford Park, Manchester, 17, may therefore be of interest.

As is well known, the rotor of a turbo-alternator consists of a cylindrical forging in which slots are machined. These slots carry mica-insulated copper strips into which the excitation current is fed through graphite brushes pressing on steel slip-rings. On a large alternator, this excitation current varies from 600 amperes at maximum rating to 250 amperes at no load, the voltage being 300. Rotors can be operated at temperatures up to about 130 deg. C., but neither thermocouples nor resistance thermometers are suitable for the continuous indication of the temperature, owing to the collecting arrangements and, in the case of resistance thermometers, owing to the fact that errors are introduced into the readings by the inevitable heating of the element. Nevertheless, the principle of resistance thermometry can be adopted by treating the whole of the rotor winding as a temperature-sensitive resistance element. In other words, if the resistance of the rotor winding is measured at a known temperature its resistance at any other temperature can be calculated; and, subject to a satisfactory method of measuring the rotor current and voltage drop, the average temperature of the winding can be ascertained. By employing a shunt, the millivolt drop of which depends on the characteristics of the associated ammeter and on the instrument lead resistance, the rotor current can be measured without serious difficulty. The measurement of the voltage drop across the rotor windings, as distinct from the total voltage between the brushes, is however, more complicated, since the brush resistance drop and the brush contact drop, both of which are appreciable on large machines, have to be discounted.

After considering all the factors involved, it is claimed that the best solution is to measure the voltage across the brush terminals and then to make allowance for the brush drop in the calibration of the instrument. While readings from a voltmeter give accurate results a calculation has to be made in each case, and if there is a tendency to sudden fluctuations in the excitation, the average of a large number of readings must be taken in order to eliminate the errors due to phase displacement, which result from the high rotor resistance. These two difficulties can, however, be avoided by using one instrument of the ohmmeter type, which has been designed to give a continuous indication of the ratio between the voltage and current and is calibrated in terms of temperature. This enables the effect of fluctuations in the circuit of the rotor to be annulled.

The instrument designed on this principle by the Metropolitan-Vickers Company is of the permanent-magnet moving-coil type. It has the advantage over those of the moving-iron pattern in that its operating current is smaller, a factor which is of importance when considering the size of the shunt to be adopted. The standard instrument is of the horizontal edgewise pattern, and is contained in a case of pressed steel which is suitable for flush, projecting or swivel mounting. It can also be fitted in the firm's standard control board case, or in any of the larger switchboard instrument cases. When vertical cases are used, the pivot friction is increased and it is therefore advisable to increase the instrument torque by raising the millivolt drop across the shunt. An illustration of the movement is given in Fig. 1, on page 392, and a diagram of the moving-coil assembly in Fig. 4, on the same page. This assembly consists of a permanent magnet *a* with soft-iron yokes *b* and two coils, one of which, *c*, is excited proportionately to the excitation voltage and the other, *d*, to the excitation current. Fig. 5 is a diagram of the rotor-temperature indicator circuit, in which the two coils are shown at *a*. As indicated at *b*, there is a swamping resistance in the current circuit, while a high resistance *c* is connected in series with the voltage coil to limit the current through the latter to a few milliamperes. In this diagram, *d* represents the voltage-circuit fuse, *e* and *f* the rotor winding and brushes respectively, *g* the shunt for the rotor-temperature indicator, and *h* the main-field circuit breaker. The small currents from the voltage and current circuits are led into their respective coils in the instrument through three "ligaments" which, for the sake of convenience, are made in the form of spiral springs. The direction of the currents through the coils is such that their torques are in opposition. The two coils are, in fact, equivalent to those of an ammeter and voltmeter moving in the same magnetic system. The pole faces of this system have, however, been machined eccentrically to the core piece, as shown in Fig. 4, in order to give a non-linear gap and distribution of flux.

The object of this non-linearity is to enable the assembly to reach equilibrium by striking a balance between the opposing torques in the two coils instead of by balancing the torque of each coil separately against springs as in a single moving-coil instrument. This condition of balance occurs when, for any position of the coils, the torque exerted by each is the product of its ampere-turns and the flux density in the gap at that point. This torque is proportional to the product of the current and flux density, since each coil has the same number of turns. If there are no other controlling forces acting on the coils, the whole assembly will move until the coils are in such a position that the flux cutting each makes the product of current and flux density the same in both. The ratio of the currents in the two coils is indicated by the position of the pointer and, as these currents are proportional to the rotor current and voltage, respectively, the scale of the instrument can be calibrated to read either rotor resistance or temperature. Since the indication is independent of the actual value of the currents passing through the coils, it follows that these can be reduced proportionally without causing a change in the position of the pointer. This would be equivalent to a change in rotor current and voltage at a fixed resistance. Consequently, the instrument gives a continuous indication of rotor temperature, independently of the actual value of the excitation, within the range that is likely to be encountered between no-load and full-load.

While the operation of a cross-coil instrument of this kind does not depend on the use of springs, to obtain a position of balance for the pointer at least three ligaments are necessary to carry the current to the two coils. Although these ligaments are made as light as possible, consistent with mechanical strength, they nevertheless exert a small torque at any position other than the natural position of rest. To overcome this biasing effect, a small permanent magnet, which is shown at *e* in Fig. 4, and can be seen in Fig. 2, is rigidly attached to the moving-coil assembly, so that it lies in the path of the leakage flux from the pole faces of the main magnet system. The ligaments are set so that, with the instrument de-energised, they pull the pointer to the centre of the scale. The compensating magnet is then adjusted, so that its magnetic axis lies along the path of the main leakage flux and its north pole faces the north pole of the main magnet. Under these conditions, the torques exerted, both by the compensating magnet and ligaments, are zero, and the pointer will remain at rest. If the pointer is now moved away from this central position the ligaments will exert a torque tending to restore it to its original position; and the value of this torque will increase directly as the angle through which the pointer is moved. At the same time, the compensating magnet, which was originally in a position of unstable equilibrium, will exert a torque tending to turn the pointer in the opposite direction. The value of this torque is a function of the strength of the compensating magnet and the sine of the angle through which the pointer has moved. As these two torques are in opposition they tend to cancel out.

Three adjustments are necessary to obtain maximum compensation. First, the fixed ends of the ligaments are rotated to pull the pointer to the centre of the scale, as when adjusting the zero on a normal moving-coil instrument. Secondly, the clamp for the compensating magnet, which is illustrated in Fig. 3, is rotated round an axis coincident with the coil-pivot axis, so as to bring the magnetic axis into line with the mean path of the leakage flux from the main poles. Thirdly, the effective strength of the compensating magnet is adjusted in relation to the strength of the leakage flux so as to make the slopes of the torque curves of the magnet and ligament approximately equal. As the net torque from the three ligaments is very weak, compared with the spring torque on a normal moving-coil instrument, the effective strength of the compensating magnet need only be small, especially as a relatively high leakage flux exists at its point of suspension.

The material from which the compensating magnet is made must, however, be of sufficiently high coercivity to prevent it from being affected by the leakage flux. It must also preferably have a low remanence, in order to facilitate handling and adjustment. The silver-manganese-aluminium alloy, known as Silmanal, has been chosen for this purpose, its coercivity being higher than that of normal permanent-magnet mater-

* ENGINEERING, vol. 161, page 14 (1946).

TEMPERATURE INDICATOR FOR ALTERNATOR ROTORS.

MESSRS. METROPOLITAN-VICKERS ELECTRICAL COMPANY, LIMITED, MANCHESTER.

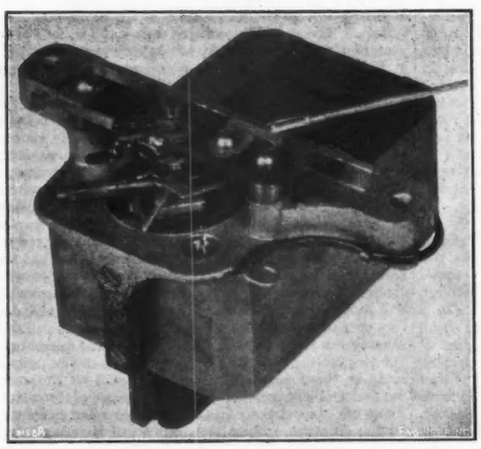


Fig. 1. Indicator Movement.

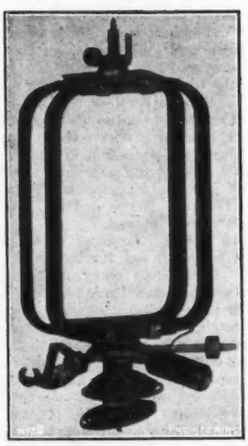


Fig. 2. Cross-Coil Assembly.

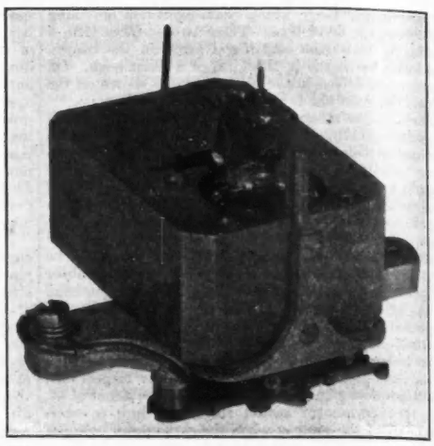
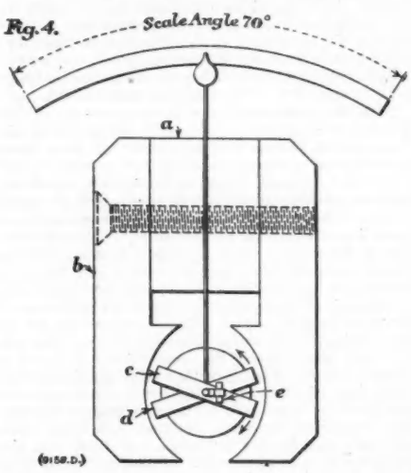
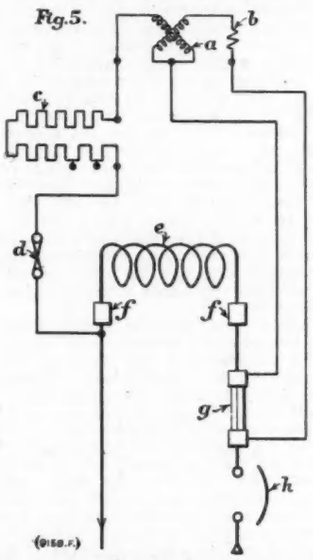
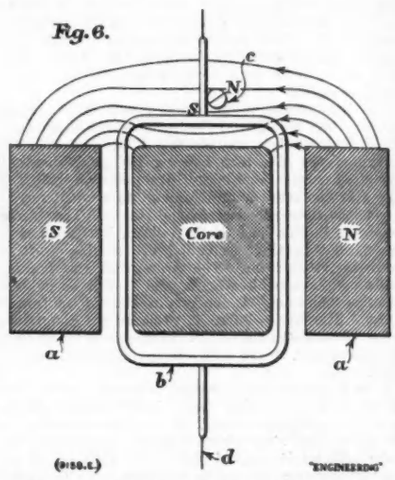


Fig. 3. Circular Clamp for Compensating Magnet.







ials, while its remanence is very low. For this reason the best results are obtained when a piece of this material is magnetised along its shortest axis and this characteristic has been employed to facilitate the adjustment of the couple exerted by the compensating magnet. The magnet is made in the form of a solid cylinder, which is about $\frac{1}{8}$ in. in diameter by $\frac{1}{4}$ in. long, and is magnetised across its diameter. The axis of the cylinder, which is at 90 deg. to its magnetic axis, is then arranged to lie parallel to the line of the pointer.

The position of the magnet in relation to the leakage flux from the main poles is shown diagrammatically in Fig. 6, in which the main poles are shown at *a*, the coil at *b*, the compensating magnet at *c*, and the axis of rotation of the coils at *d*. From this diagram it will be seen that, as the cylindrical magnet is rotated about its geometric axis, it moves through a position in which its magnetic axis is parallel to the lines of the leakage flux to one in which its magnetic axis is parallel to the axis of rotation of the coil assembly. The couple exerted by the compensating magnet can therefore be varied from a maximum to zero by rotating the magnet through 90 deg. Thus, if the compensating magnet is made stronger than necessary, the effect of its couple is easily reduced in order to obtain the desired degree of compensation.

The voltage drop between the slip-rings and the brush-holder carrier is a function of the resistance of the brush material and the contact resistance between the slip-rings and the brushes. Measurements taken over a period of several months on a large turbo-alternator under operating conditions indicate that the voltage drop across the brushes varies about $\pm$ 20 per cent. from a mean value, and that this variation bears no direct relation to the current which the brushes are carrying at any time. No allowance can therefore be made for this variation in the calibration of the instrument; its effect must be accepted as an error in indication. The mean figure for brush drop can, however, be predicted and an allowance made for it. It generally lies between a total of 3 and 4 volts for both brushes, and a 20 per cent. variation is therefore a relatively small amount compared with the total voltage across the rotor. The tendency for the total brush drop to remain constant under varying conditions of excitation leads to errors in indication when the excitation is low, if the instrument has been calibrated at full excitation. This can be offset by adjusting the ligament compensation with a constant biasing torque, so that while the instrument is calibrated to give maximum accuracy under full-load excitation the error caused by the higher percentage of brush drop under conditions of reduced excitation is compensated. A further advantage of this additional biasing torque is that it causes the pointer to return to zero when the instrument is de-energised. In the fully compensated instrument, the pointer remains in any position on the scale, thus tending to confusion.

Two factors have to be considered in deciding on the size of shunt to be used. These are the temperature coefficient and the instrument-operating torque. The voltage coil needs no compensation for temperature, since its resistance, which is about 3 ohms, is negligible in comparison with its series resistance, which has a value of between 10,000 and 20,000 ohms, and it is made from wire with a negligible temperature coefficient. Since the instrument has been calibrated to indicate temperatures by measuring the change in resistance of a copper circuit, it follows that, if its own circuit is composed entirely of copper, changes in instrument temperature will cause equal errors in the pointer indication. It has therefore been decided to ensure that the coefficient of the instrument does not exceed 0·1 per cent. per degree. This necessitates a higher proportion of swamping resistance and a greater millivolt drop from the shunt than would be the case in an ammeter. The minimum permissible operating torque is the limiting factor in deciding the smallest shunt which may be used, and there must be sufficient millivolts available to operate the instrument at no-load excitation currents. Under normal conditions, with a horizontal edgewise instrument and a lead resistance of about 0·15 ohm, satisfactory operation can be obtained with a shunt giving 200 millivolts at full-load.

In generating stations where there are two or more machines of the same type, rotors are sometimes interchanged to facilitate maintenance programmes. It is desirable, therefore, that the indicators should be easily adjustable to the characteristics of each machine, in order to avoid the complication of having to interchange instruments. This requirement is relatively simple to meet, provided the currents corresponding to full-load excitation for each rotor do not vary widely, by adjusting the resistance in series with the voltage coil so that the ampere-turns in this coil for a given temperature with one rotor, are the same as they would have been for the other rotor at the same temperature. Under certain conditions caused perhaps by heavy fluctuations in load or slight governor hunt, it may be found that fluctuations occur in both the rotor volts and current. Owing to the high reactance of the rotor, these changes in current are out of phase with those of the voltage, the result being the production of excessive swings at the indicator. These swings can be overcome by the use of very heavy magnetic damping, which makes it possible for satisfactory readings to be obtained. As regards performance, it is stated that on a temperature scale of 0 deg. to 150 deg. C., the error should be less than $\pm$3 per cent. between 100 per cent. and about 60 per cent. of full-load conditions and should not exceed $\pm$5 per cent. under all conditions of excitation and reasonable variation in the main brush drop.

SOUTHERN RAILWAY CHANNEL STEAMER "FALAISE."

MESSRS. W. DENNY AND BROTHERS, LIMITED, DUMBARTON.

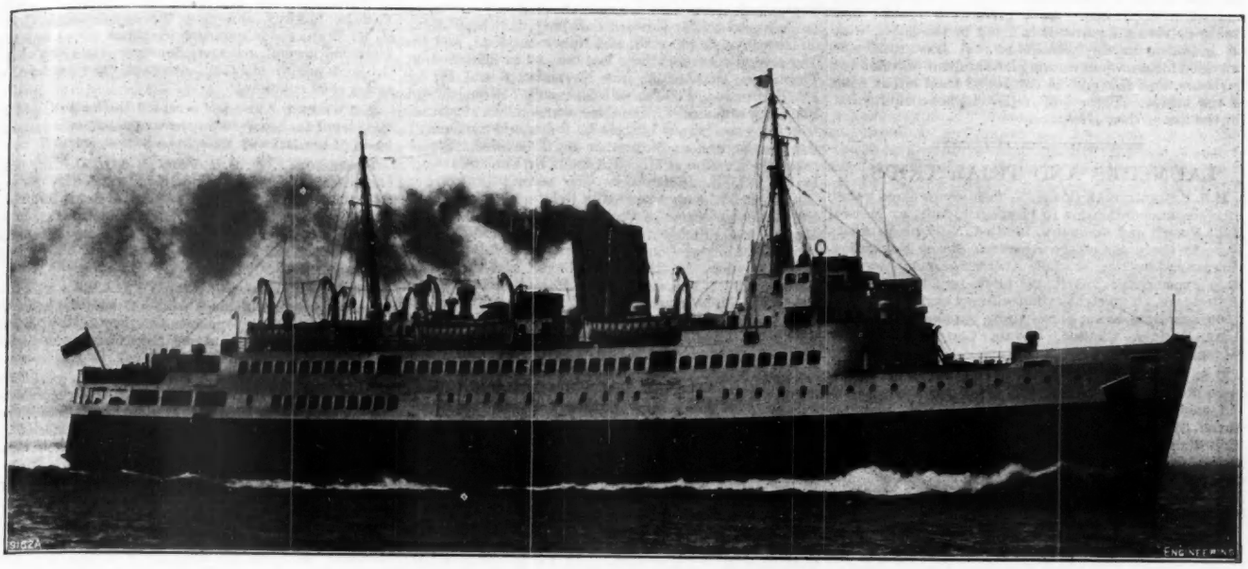


FIG. 1.

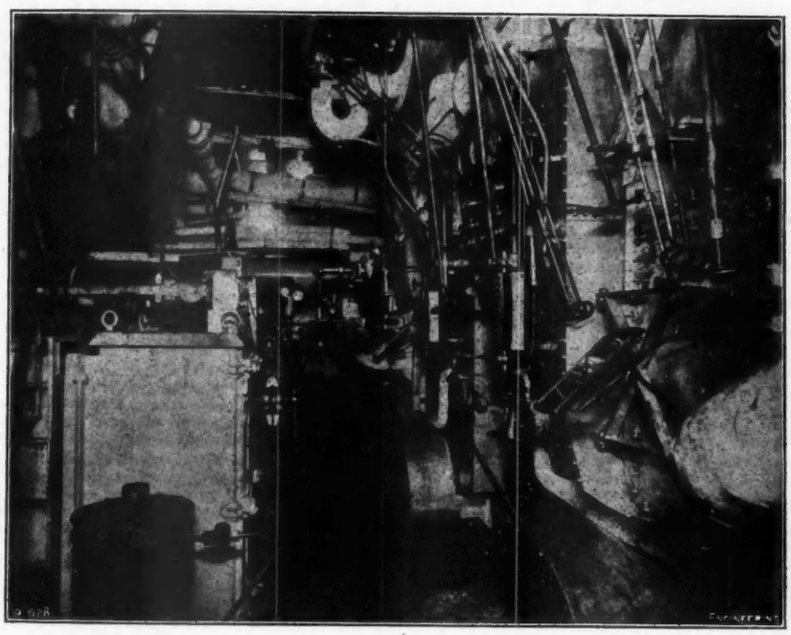


FIG. 2.

THE SOUTHERN RAILWAY CHANNEL STEAMER "FALAISE."

IN July last, the Southern Railway Company put into service on the Southampton-St. Malo-Channel Islands routes the steamer Falaise, shown on her trial trip in Fig. 1, above. She is the first post-war addition to the company's fleet and has been designed to run on any of the cross-Channel services run by the Southern Railway, though she will operate mainly from Southampton, where she attracted favourable comment from the members of the Institution of Naval Architects during their recent meeting there.

The Falaise has been built and engined by Messrs. William Denny and Brothers, Limited, Dumbarton. Her dimensions are: length overall, 314 ft.; breadth, 48 ft.; depth, 17 ft. 6 in.; draught, 12 ft. 6 in.; tonnage, 3,710 gross; displacement, 2,720 tons. Accommodation is provided for 1,400 passengers. The 'midship portion of the promenade deck, forward and aft of the boiler casing and on each side of it, is devoted to lounges, and the forward and after ends of this deck to smoke rooms. On the upper deck, beneath the after lounge and smoke room, is a dining saloon, abaft of which is the accommodation for petty officers, together with the galley and pantries. Forward of the dining saloon are cabins, extending for rather more than half the length of this deck, and other cabins are disposed on the main and lower decks. The lounge for third-class passengers is immediately below the dining saloon. On this deck also are the crew's quarters, all consisting of two-berth cabins, and, forward, space for motor cars. The officers' cabins are all on the boat deck. The public rooms throughout are air-conditioned.

The propelling machinery consists of two sets of Parsons single-reduction geared turbines, supplied with steam by two oil-fired Foster Wheeler boilers, arranged athwartship and fitted with superheaters and economisers; the working pressure is 450 lb. per square inch and the steam temperature is 750 deg. F. Each boiler has a generating surface of 6,950 sq. ft. and each superheater 950 sq. ft. The turbines develop between 9,000 and 10,000 shaft horse-power, giving a speed of 20½ knots, which is about one knot more than previous vessels on the Southampton services. The propellers are of bronze. A vertical auxiliary boiler, also oil-fired, is fitted on the starboard side of the boiler room to supply steam for the "hotel" services. The oil-fuel bunkers are situated on the forward side of the forward boiler-room bulkhead, on each side of the centre line, and next to each bunker is a cargo oil tank. The vessel is fitted with an improved form of the Denny-Brown stabiliser, and these are accommodated, with the operating mechanism, against the after bulkhead of the boiler-room. Other auxiliaries in the boiler room are the oil-fuel units and auxiliary feed pumps for the main and auxiliary boilers, an oil-fuel transfer pump, an emergency bilge pump, an air compressor, a sewage ejector, and a calorifier. Distilled-water tanks are fitted in the boiler-room wings, and the small electric and hand oil-fuel units for lighting-up are arranged on the firing platform, a view of which is given in Fig. 2, herewith. The air supply to the boilers is on the closed-stokehold system, the forced-draught fans, which are electrically driven, being on a flat above the engine-room starting platform. Each boiler has five oil-fuel burners.

The arrangement of the main turbines follows the usual plan, with the high-pressure and low-pressure turbines at the forward end of the gearcase with the condensers beneath, the high-pressure turbines being inboard. Forward of each set of main engines is a group of auxiliary machinery consisting of a turbo-feed pump, extraction pump, circulating pump, air ejector, and a small condenser for the gland steam. The manœuvring valves are in the centre of the starting platform, in front of a panel carrying the usual gauges; and between the gauge panel and the forward bulkhead of the engine room are the two bilge and ballast pumps. A sanitary pump is at the forward end of the starboard wing space and a drain cooler in the corresponding position on the port side. The forced-lubrication pumps are between the two gearcases; and farther aft, between the shafts, are, starboard of the centre line, a turbo-generator set and an oil cooler, and, on the port side, an air compressor and a sewage ejector. The space between the shafts here forms a recess between two wing fresh-water tanks. A tank containing fuel oil for the 200-kW Diesel-engined emergency generator set (situated on the main deck, abaft the forced-draught fans) is located on the port side; and, also at the after end of the engine room, there are two drain tanks for lubricating oil and a sewage drain tank. Two more generator sets are located in the engine-room wings abreast of the gearcases, a turbine-driven set being on the port side and a Diesel-driven set on the starboard side. The main switchboard is arranged athwartship at the after end of the engine room, on a

flat above the shafts; behind and below it, on the port side, is an evaporator and, to starboard, an air compressor and receiver. The fresh-water pump and the evaporator feed pump are in the port wing.

Navigating and other ship equipment includes a Chernikeeff log, a Fathometer, a radio direction-finder, and radar apparatus. As a precaution against fire, smoke-detecting apparatus is fitted in the holds, with an indicator in the wheelhouse. A bow rudder is provided for use when working into and out of restricted harbours, and this can be controlled from either wing of the bridge. There is a radio-telephone equipment for the use of the passengers.

LAUNCHES AND TRIAL TRIPS.

M.S. "Caledonian Coast."—Twin-screw cargo vessel with accommodation for 10 passengers, built by Messrs. Hall, Russell and Company, Limited, York-place, Aberdeen, to the order of the Aberdeen Steam Navigation Company, Limited, for their Aberdeen-London service. Main dimensions: 265 ft. by 40 ft. by 23 ft. 6 in. to shelter deck. Two eight-cylinder Diesel engines of about 2,560 aggregate brake horse-power, supplied by British Polar Engines, Limited, Govan, Glasgow. Launch, September 30.

M.S. "Melbourne Star."—Twin-screw refrigerated cargo liner, with accommodation for 12 passengers, built and engined by Messrs. Harland and Wolff, Limited, Govan, Glasgow, for the Blue Star Line, Limited, London. Main dimensions: 540 ft. by 70 ft. by 43 ft. 4½ in. to shelter deck; gross tonnage, about 13,500; loaded draught, 30 ft. 6 in. Harland-B. and W. eight-cylinder double-acting two-cycle Diesel engines. Launch, October 2.

M.S. "Soudan."—Twin-screw cargo vessel, with accommodation for 12 passengers, built and engined by Messrs. Barclay, Curle and Company, Limited, Whiteinch, Glasgow, for the Peninsular and Oriental Steam Navigation Company, London. Main dimensions: 525 ft. by 67 ft. by 43 ft. to shelter deck; gross tonnage, 10,700. Two sets of Barclay, Curle-Doxford six-cylinder opposed-piston oil engines of 13,600 aggregate brake horse-power, to give a service speed of 18 knots. Launch, October 7.

S.S. "Blankvann."—Single-screw cargo vessel, built by Messrs. Short Brothers, Limited, Pallion, Sunderland, for Messrs. Jacobsen and Salvesen, Oslo. Main dimensions: 441 ft. 6 in. overall by 57 ft. by 36 ft. 10 in. to shelter deck; deadweight capacity, about 9,125 tons on a draught of 25 ft. 1½ in. Triple-expansion engine of reheat design supplied by Messrs. George Clark (1938), Limited, Sunderland, associate firm of the North Eastern Marine Engineering Company (1938), Limited, Wallsend-on-Tyne, to give a service speed of 11 knots. Trial trip, October 7.

Floating Dock.—Additional section for the 7,500 tons capacity six-section floating dock, built by Messrs. Furness Shipbuilding Company, Limited, Haverton Hill-on-Tees, for Aktiebolaget Finnboda Varf, Stockholm. The new section extends the length of the dock to 538 ft. overall and increases the lifting capacity to 9,000 tons. Delivered in Stockholm, October 8.

M.S. "Thorshavet."—Twin-screw whale factory ship, built and engined by Messrs. Harland and Wolff, Limited, Belfast, for A/S Thor Dahl, Sandefjord, Norway. Main dimensions: 560 ft. by 77 ft. by 39 ft. 6 in. to factory deck; deadweight capacity, 21,000 tons, on a mean summer draught of 34 ft. 6 in. Harland-B. and W. six-cylinder four-cycle Diesel engines. Trial trip, October 9.

M.S. "Brazza."—Twin-screw passenger and cargo vessel, built and engined by Messrs. Swan, Hunter, and Wigham Richardson, Limited, Walker, Newcastle-on-Tyne, to the order of the French Government, for the Compagnie Chargeurs Réunis, Paris. Main dimensions: 448 ft. by 61 ft. 9 in. by 34 ft. 6 in. to upper deck; deadweight capacity, 5,400 metric tons on a draught of 22 ft. 4 in. Two sets of Swan, Hunter-Doxford opposed-piston two-stroke Diesel engines. Launch, October 14.

M.S. "Borealis."—Single-screw cargo vessel, built by Messrs. Smith's Dock Company, Limited, South Bank-on-Tees, to the order of Messrs. Den Norske Middelhavslinje A/S, Oslo. Main dimensions: 350 ft. by 53 ft. by 31 ft. to upper deck; deadweight capacity, about 4,100 tons on a mean draught of 20 ft. Doxford opposed-piston oil engine of 3,000 brake horse-power, supplied by Messrs. North Eastern Marine Engineering Company (1938), Limited, Wallsend-on-Tyne. Launch, October 14.

M.S. "Pelayo."—Single-screw general cargo vessel, built and engined by Messrs. William Doxford and Sons, Limited, Sunderland, for Messrs. MacAndrews and Company, Limited, London. Main dimensions: 330 ft. by 50 ft. by 19 ft. 4 in. to second deck; deadweight capacity about 3,420 tons on a draught of 19 ft. Doxford opposed-piston five-cylinder oil engine. Trial trip, October 14.

ROYAL INSTITUTION LECTURES.

Four courses of afternoon lectures, beginning at 5.15 p.m., are to be held at the Royal Institution of Great Britain, 21, Albemarle-street, London, W.1, before Christmas. The first course, entitled "The Vegetation of the Chalk," consists of four lectures, to be delivered by Sir Edward Salisbury, C.B.E., F.R.S., on Tuesdays, October 28, and November 4, 11, and 18. The second course of three lectures, to be delivered on Thursdays, October 30, and November 6 and 13, by Dr. E. Orowan, F.R.S., will deal with "Strength and Plasticity of Solids." The third course, of four lectures, will concern "Cross-Linking in Polymeric Systems;" the first lecture, on November 20, is entitled "Structural Modification of High Polymers by Vulcanisation," by Dr. G. F. Bloomfield. The second lecture, on November 17, deals with "The Relation of Mechanical Properties to Degree of Cross-Linking in Rubbers," by Dr. L. R. G. Treloar. The third lecture, on "Cross-Linking of Vinyl Compounds," will be delivered on December 4 by Dr. H. P. Staudinger, and the fourth lecture, on "Cross-Linking in Phenol-Formaldehyde Resins," will be given by Mr. E. G. K. Pritchett on December 11. The fourth course of afternoon lectures is entitled "The Development of Astronomical Instruments from Early to Modern Times," and consists of three lectures to be delivered on Tuesdays, November 25 and December 2 and 9, by Sir Harold Spencer Jones, F.R.S. The fees for non-members of the Institution for courses of three lectures is 6s., and for courses of four lectures, 8s. Tickets for single lectures are 2s. 6d., and for all courses before Christmas 1l. 1s. The 118th course, of six Christmas lectures, adapted to a juvenile audience, will be given by Professor E. K. Rideal, M.B.E., F.R.S., at 3 p.m., on Saturdays, Tuesdays and Thursdays, December 27 and 30 and January 1, 3, 6 and 8. The subject will be "Chemical Reactions: How They Work," and the fees payable by non-members are: Children (from 10 to 17), 10s. 6d., and adults, 1l. 1s.

BOOKS RECEIVED.

Thirty-Ninth Annual Report of The Hydro-Electric Power Commission of Ontario for the Year Ended October 31st, 1946. Offices of the Commission, 620, University-avenue, Toronto 2, Ontario, Canada.

The British Fuel and Power Industries: A Report by P.E.P. The Director, P.E.P. (Political and Economic Planning), 16, Queen Anne's-gate, Westminster, London, S.W.1. [Price 30s. net.]

Radio: A Study of First Principles. For Schools, Evening Classes and Home Study. By Elmer E. Burns. Third edition. D. van Nostrand Company, Incorporated, 250, Fourth-avenue, New York, U.S.A. [Price 3 dols.] Macmillan and Company, Limited, St. Martin's-street, London, W.C.2. [Price 15s. net.]

Regelungstheorie. By Jost Hänny. A.-G. Gebr. Leemann & Co., Stockerstrasse 64, Zürich 2. [Price 23 Swiss francs.]

Metropolitan Water Board. Floods in the Lee Valley, March, 1947. Reports by H. F. Cronin, Chief Engineer, and Lieut.-Colonel E. F. W. Mackenzie, Director of Water Examination. The Clerk of the Board, Metropolitan Water Board, New River Head, Rosebery-avenue, London, E.C.1.

The Machinists' and Draftsmen's Handbook. By Albert W. Wagener and Harlan R. Arthur. Third printing. D. van Nostrand Company, Incorporated, 250, Fourth-avenue, New York, U.S.A. [Price 5·60 dols.] Macmillan and Company, Limited, St. Martin's-street, London, W.C.2. [Price 28s. net.]

Department of Scientific and Industrial Research. Decay of Timber and Its Prevention. By K. St. G. Cartwright and Dr. W. P. K. Findlay. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 12s. 6d. net.]

Pressure Vessels for Industry. Construction, Design, Inspection and Safety Practices, with the Important Pressure Vessels of Many Industries. By Harry M. Spring, Junr. McGraw-Hill Book Company, Incorporated, 330, West 42nd-street, New York 18, U.S.A. [Price 3·50 dols.] McGraw-Hill Publishing Company, Limited, Aldwych House, Aldwych, London, W.C.2. [Price 17s. 6d.]

The Reinforced Concrete Association. Technical Paper No. 5. *Prestressed Reinforced Concrete.* By K. Billig. Offices of the Association, 94/98, Petty France, Westminster, London, S.W.1. [Price 5s.]

Newnes Metric and Decimal Tables. By F. J. Camm. George Newnes, Limited, Tower House, Southampton-street, Strand, London, W.C.2. [Price 3s. 6d. net.]

Electro-Technology and Calculations. Basic Theory and Circuit Calculations for Electrical Engineers. By Dr. M. G. Say. George Newnes, Limited, Tower House, Southampton-street, Strand, London, W.C.2. [Price 6s. net.]

British Chemical Plant, 1947 to 1948. British Chemical Plant Manufacturers Association, 26, Portland-place, London, W.1. [Free to approved applicants.]

PERSONAL.

Consequent upon the appointment of Mr. V. M. Barrington-Ward, D.S.O., M.Inst.T., and Mr. J. C. L. Train, M.C., M.I.C.E., to membership of the Railway Executive to be set up under the Transport Act, 1947, as noted on page 274, *ante*, the London and North Eastern Railway announce the appointment of Mr. C. K. Bird, goods manager (Southern Area) as acting divisional general manager (Southern Area) and of Mr. G. B. Barton, M.I.C.E., assistant chief engineer, as acting chief engineer.

Sir Wilfrid Ayre has accepted the invitation of the Minister of Transport to become a member, on a part-time basis, of the Railway Executive.

Professor J. A. S. Ritson, D.S.O., O.B.E., B.Sc., of the Royal School of Mines, London, S.W.7, has been elected President of the Institution of Mining Engineers, Salisbury House, Finsbury-circus, London, E.C.2, for the session 1948-49, in succession to Professor Douglas Hay, M.C., B.Sc. The President-elect will take office in January, 1948.

Sir Frank Mears, P.R.S.A., F.R.I.B.A., who is at present a member of the Amenity Committee under the Hydro-Electric Development Act, has been appointed chairman in place of Colonel the Hon. Ian Campbell, D.S.O., who has resigned.

Mr. Howard Bird has relinquished his position as director and managing director of the Consolidated Pneumatic Tool Company, Limited, 232, Dawes-road, London, S.W.6. Mr. J. A. Owen, M.I.Mech.E., a director of the company, has been appointed managing director.

Mr. H. H. Hagan has been co-opted a member of the Council of the Institution of Engineers and Shipbuilders in Scotland, 39, Elmbank-crescent, Glasgow, C.2, to fill the vacancy created by the election of Dr. J. M. McNeill, M.C., to the Presidency of the Institution. Mr. Hagan will serve for the unexpired period of Dr. McNeill's term of office as a member of Council.

Mr. H. N. Darlington has taken up the position of chief engineer to the Anchor Chemical Company, Limited, Clayton, Manchester.

Mr. R. P. Horlock, B.Sc. (Eng.) (Lond.), A.C.G.I., M.I.E.E., formerly manager of the sub-office of the Metropolitan-Vickers Electrical Company, Limited, at Leeds, has been appointed manager of the company's district office at Sheffield. He thus succeeds Mr. R. G. MacLaverty, who has retired after 44 years of service with the company. Mr. W. H. Ball has been appointed to succeed Mr. Horlock as manager of the Leeds sub-office, which is now attached to the Sheffield district office of the company's organisation.

Mr. H. K. Suttle has been appointed senior lecturer in chemical engineering at Loughborough College, Leicestershire.

Mr. E. J. Edwards, of the chassis-inspection department, the Associated Equipment Company, Limited, Southall, Middlesex, has left this country for Johannesburg, to join the works personnel of Messrs. Dowson and Dobson, Limited, distributors of the Associated Equipment Company's products in South Africa.

Professor Frederick Soddy, F.R.S., has changed his address from "Knapp," Enstone, Oxfordshire, to 48, Langdale-road, Hove, 3, Sussex.

The Aluminium Plant and Vessel Company, Limited, Wandsworth-park, London, S.W.18, have purchased the business of Paramount Alloys Limited, Slough, and will operate it as an independent subsidiary in order to meet their increasing requirements in stainless-steel castings.

The Non-Ferrous Metals Directorate (Disposals) of the Ministry of Supply have removed from 31-43, Norfolk-square, to 2, Hyde Park-street, London, W.2. The new telephone number is AMBassador 1290 and the telegraphic address remains Metrol Padd London.

Associated British Oil Engines, Limited, Duke's-court, 32, Duke-street, London, S.W.1, have appointed four divisional sales managers. Mr. R. Hunter, M.I.Mar.E., will handle marine engines; Mr. E. Leslie Brooks, A.M.I.Mech.E., Assoc.I.E.E., heavy engines; Mr. R. F. Norris, medium engines; and Mr. J. C. Gale, small engines. Each is directly responsible to the general sales manager, Mr. A. P. Quarrell, M.I.Mar.E., A.M.I.Mech.E.

The P.D.N. Castle Engineering Company, Limited, 87, Pembury-road, Tottenham, London, N.17, have been appointed the sole export agents for Messrs. Hedleys, Limited, Forward Works, Bell-street, W. Bromwich.

Recent Developments in Welding: Erratum.—The name of the author of the paper on "The Development and Application of Stud Welding," which was presented at the autumn meeting of the Institute of Welding and summarised on page 367, *ante*, is Mr. A. H. Bent, and not Burt as stated.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel.—Output is maintained at a high level and the mills provide a full quota of the increased British output. Nevertheless, doubts are growing regarding supplies of raw materials. While coal supplies have been fairly good in past weeks, coke has been in short supply. One or two cargoes have been going to Eire, but this may be stopped in order to start up a new blast-furnace at Clyde Iron Works. Coke-oven supplies determine the pig-iron output, shortage of which puts a brake on steel production. If the Clyde Iron Works furnace opens up, this should ease the position. In Scottish steelworks, however, considerable use is made of scrap. This, too, is in very short supply, and it is feared that, if extra tonnages are not obtained from elsewhere, heavier calls will have to be made on pig iron, with a consequent higher production cost. The general demand for steel is undiminished and in some cases is actually increasing. Export business will assume increasing importance as the intensified drive gets under way.

Scottish Coal.—At the time of writing, 8,000 men in the Lanarkshire pits are on strike in support of their demand for increased wages. They were on strike three weeks ago for the same reason, and went back to work on the assumption that their demands would be covered by some move by October 17; now they allege that the negotiations are too slow and unsatisfactory. It is anticipated that the drop in output will be about 8,000 tons a day. So far the only place affected is Lanarkshire. Prior to this strike, the Lanarkshire mines had been free of stoppages for about three weeks and output was at about the 455,000 tons a week level. Priority users were therefore receiving their full allocations and other users were getting slightly better deliveries. This was partly retarded by shortage of wagons, many of which were engaged in moving cargoes of American coal from the Glasgow docks. Scottish miners are still considering the longer working week and the problem they are engaged on is whether to work an eleven-day fortnight or half an hour extra each shift. It is thought that they will choose the former, and, under normal conditions, this would mean an additional output of about 70,000 tons a fortnight.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—More coke is reaching the blast-furnaces as a result of the further increase in coking-coal allocations. The production of pig-iron has been increased, and the coke-fired crucible-steel furnaces have been better served. Electric melting, however, is supplanting the coke-fired crucible process in some cases. All types of steel are in short supply and some steel users are able to operate their plants at only about 60 per cent. of the potential capacity. The alteration in steel allocations are upsetting old programmes and depriving home-trade departments of steel. There is a marked scarcity of stainless steel, especially in sheet form, and steps have been taken to push on with the extensions to plant which were approved some time ago. The demand for heavy and light machine tools is strong and continuous, and engineering firms are well booked in this section. The completion of the reorganisation of some iron and steel foundries is being retarded by delays in delivery of new mechanisation plant. Further increase in prices is foreshadowed for coal now being brought into Sheffield, for power stations and industrial concerns, by road haulage from Nottinghamshire and Derbyshire collieries, owing to lack of sufficient railway wagons. Further orders have been received by agricultural-steel firms making machine parts and edge tools, and all tool factories are very busily employed.

South Yorkshire Coal Trade.—The outputs of deep-mined and opencast coal have increased, and production from a drift mine has also expanded. Efforts are being made to replenish stocks at industrial concerns, all of which have lower reserves than planned. Additional allocations of coking coal are being made and the coke-works, at full heats, are increasing the make of coke and the supply of coke-oven gas. Locomotive hards are in very strong request. House-coal allocations are below requirements, but gas coal is coming forward fairly well. Alternative fuels, such as washery fines for firing Lancashire boilers, are moving freely.

FOURTH PLENARY WORLD POWER CONFERENCE.—The International Executive Council of the World Power Conference, at their recent meeting at The Hague, decided unanimously to accept an invitation from the British National Committee to hold the Fourth Plenary World Power Conference in London in 1950. The offices of the British National Committee are at 201-2, Grand Buildings, Trafalgar Square, London, W.C.2.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Welsh Coal Trade.—During 1946 the South Wales coalfield contributed 13,231,391*l.* to the Coal Charges Account and recovered from the fund, to meet the cost of wages, materials, etc., and the owners' standard credit balances, 19,838,859*l.* a deficiency of more than 6,600,000*l.* The deficiency was equal to 7*s.* 8¼*d.* per ton compared with 7,176,000*l.* (8*s.* 7¼*d.* per ton) in 1945. The Account was created in 1942 when the system of Government control and financial stabilisation was introduced, under which the richer coalfields subsidised the poorer. According to statistics issued by the Ministry of Fuel last week, the total proceeds of the South Wales coalfield in 1946 were 37,000,000*l.*, although 42,000,000*l.* was needed to meet costs of production and an additional 1,250,000*l.* to pay the colliery owners' average profit of 1*s.* 5¼*d.* per ton. Business remained within narrow limits on the Welsh steam-coal market last week, in spite of the fact that salesmen encountered a keen demand from inland users. Outputs at the collieries have been well maintained at recent improved levels, but there was insufficient coal to meet all needs. The highest priority users made heavy calls and the bulk of present productions was steadily absorbed by deliveries to these consumers. After these needs had been met there was not enough coal for ordinary users and operators had to scrutinise all new business carefully before accepting new orders for early delivery. In a number of instances, coal intended for delivery to certain users had to be directed elsewhere to meet pressing needs. In view of the shortage of coals, general export trade was impossible. Limited quantities were released for delivery to special consumers in Eire and Canada, but no other shipments could be made. Cokes and patent fuel were in very keen demand but supplies are almost completely unobtainable.

Swansea Steel-Sheet Industry.—The market report issued by the Incorporated Swansea Exchange states that, last week, there was little, if any, change in the condition of the tin-plate market. Less business was transacted with home consumers, but this was offset by a much larger number of export orders placed for delivery during the current quarter. Steel sheets are still a very strong feature of the market, and makers, already heavily committed, are inundated with offers of orders. Iron and steel scrap is in strong demand, more particularly the heavier and better qualities.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

General Situation.—The outputs of iron and steel are increasing, but arrears of delivery are very heavy and the distributable tonnage is still much below customers' requirements. The demand for larger supplies continues, and efforts are being made to maintain as full activity as conditions permit at coke ovens, blast furnaces, steel-melting shops, and re-rolling mills. Larger supplies of native ironstone would be welcome, but satisfactory parcels of high-grade foreign iron ore are coming to hand and the October production of Tees-side iron and steel works compares favourably with that of September. Good-quality iron and steel scrap is in great demand, and the increasing supplies are not sufficient to meet the users' pressing needs. Pig-iron continues in greater demand than producers can supply, and distributable parcels of finished commodities are readily taken up.

Foundry and Basic Iron.—Complaints of serious scarcity of ordinary foundry pig-iron continue. The shortage is still gravely impeding operations at plants turning out much needed commodities and necessitates the very extensive use of cast-iron scrap. The output of basic iron is on a somewhat increased scale, but there is a persistent demand for larger direct deliveries to the makers' own consuming departments.

Hematite, Low-Phosphorus and Refined Iron.—East-Coast hematite manufacturers are managing to keep pace with the demand, but the available parcels of low- and medium-phosphorus grades of iron are inconveniently short of requirements. The output of refined iron is well taken up.

Manufactured Iron and Steel.—Manufacturers of semi-finished and finished iron have well-filled order books, and steelmakers' commitments are still embarrassingly heavy. Firms turning out steel semies cannot deal adequately with the re-rollers' urgent requirements. The demand is greatest for prime sheet bars and billets, although any inferior crops that come on the market are unhesitatingly accepted; available parcels of foreign products are readily taken up. The improved production of finished descriptions of steel is being maintained. Makers of black and galvanised sheets are busily occupied, as also are firms engaged in the production of railway requisites and colliery equipment. Shipbuilders have a vast amount of work in hand, largely for buyers overseas, and are expecting larger allocations of steel than have been coming to hand.

NOTICES OF MEETINGS.

IT is requested that particulars for insertion in this column shall reach the Editor not later than Tuesday morning in the week preceding the date of the meeting.

INSTITUTION OF ELECTRICAL ENGINEERS.—Monday, October 27, 5.30 p.m., Victoria-embankment, W.C.2. Discussion on "Standardisation in the Electrical Industry," opened by Mr. P. Good. *North-Eastern Centre:* Monday, October 27, 6.15 p.m., Neville Hall, Newcastle-upon-Tyne. "Standardisation of Switchgear," by Messrs. D. E. Lambert and J. Christie. *South Midland Radio Group:* Monday, October 27, 7 p.m., James Watt Institute, Birmingham. "Practical Waveguides," by Dr. L. G. H. Huxley. *Scottish Centre:* Tuesday, October 28, 6.15 p.m., Royal Technical College, Glasgow. "Application of Electrical Technique to the Service of Other Industries," by Messrs. H. Cobden Turner and G. M. Tomlin. *North-Western Centre:* Wednesday, October 29, 6.45 p.m., Harris Institute, Preston. "Experience on the Irish Electricity Supply System," by Messrs. A. Burke, R. C. Cuffe and W. O'Neill. *Sheffield Sub-Centre:* Wednesday, October 29, 6.15 p.m., Royal Victoria Station Hotel, Sheffield. "Gas, Electricity and Coal Economy," by Mr. P. Schiller.

INSTITUTION OF THE RUBBER INDUSTRY.—*Manchester Section:* Monday, October 27, 6.15 p.m., Engineers' Club, Manchester. "Latex Treatment," by Mr. B. G. Darnton.

JUNIOR INSTITUTION OF ENGINEERS.—*Sheffield Section:* Monday, October 27, 7.30 p.m., 198, West-street, Sheffield. Annual Meeting. "Plastics," by Mr. W. E. Amies. *Institution:* Friday, October 31, 6.30 p.m., 39, Victoria-street, Sheffield. "Rubber in Engineering," by Mr. F. M. Panzetta. *North-Western Section:* Saturday, November 1, 2.30 p.m., 16, St. Mary's Parsonage, Manchester. "Patents from the Layman's Point of View," by Mr. L. H. A. Carr.

INSTITUTION OF CIVIL ENGINEERS.—Tuesday, October 28, 5.30 p.m., Great George-street, Westminster, S.W.1. "Roads and Their Riding Qualities," by Mr. W. J. O. Scott. *Glasgow Association:* Friday, October 31, 6.15 p.m., 39, Elmbank-crescent, Glasgow, C.2. "The Boulder Dam Project," by Mr. A. C. Gardner.

SHEFFIELD METALLURGICAL ASSOCIATION.—Tuesday, October 28, 7 p.m., 198, West-street, Sheffield. "Photoelasticity Applied to Design Problems," by Mr. R. B. Heywood.

INSTITUTE OF WELDING.—Wednesday, October 29, 6 p.m., Institution of Civil Engineers, Great George-street, S.W.1. Presidential Address, by Mr. J. L. Adam.

INSTITUTE OF BRITISH FOUNDRYMEN.—*London Branch:* Wednesday, October 29, 7.30 p.m., Waldorf Hotel, Aldwych, W.C.2. "Production of Cast Crankshafts," by Mr. R. B. Templeton. *Falkirk Section:* Friday, October 31, 7 p.m., Temperance Café, Lint Riggs, Falkirk. "Protection of Metals Against Corrosion," by Messrs. W. Westwood and R. I. Higgins.

ROYAL AERONAUTICAL SOCIETY.—Thursday, October 30, 6 p.m., Institution of Civil Engineers, Great George-street, S.W.1. Third British Commonwealth Lecture, by Mr. James Bain.

INSTITUTION OF ENGINEERS-IN-CHARGE.—Thursday, October 30, 6.30 p.m., St. Bride Institute, Fleet-street, E.C.4. Presidential Address, by Lieut.-Col. J. D. K. Restler.

ROYAL STATISTICAL SOCIETY.—*Industrial Applications Section:* Thursday, October 30, 6.30 p.m., University, Sheffield. "Application of Regression Analysis to Industrial Problems," by Mr. P. Lyle.

INSTITUTION OF MECHANICAL ENGINEERS.—Friday, October 31, 5.30 p.m., Storey's-gate, St. James's Park, S.W.1. "The Manufacture of Turbine Blades for the Whittle Engine," by Mr. T. A. Kestell. AUTOMOBILE DIVISION. *Birmingham Centre:* Tuesday, October 28, 7 p.m., James Watt Institute, Birmingham. "Design, Development and Production of High-Speed Compression-Ignition Engines," by Messrs. S. Markland and N. Tattersall. *London Graduates' Section:* Wednesday, October 29, 6.30 p.m., Storey's-gate, St. James's Park, S.W.1. "Motor-Cycle Design of To-day and To-morrow," by Mr. Arthur Bourne. *North-Western Centre:* Wednesday, October 29, 7.15 p.m., Engineers' Club, Manchester. "Recent Developments in Automobile Transmissions," by Professor E. M'Ewen.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—Friday, October 31, 6.15 p.m., Literary and Philosophical Society, Newcastle-upon-Tyne. Sixteenth Andrew Laing Lecture: "A Marine Turbine Research and Testing Station," by Dr. T. W. F. Brown.

INSTITUTE OF METALS.—*Sheffield Section:* Friday, October 31, 7.30 p.m., University, Sheffield. "Electroplating Problems," by Mr. A. W. Hothersall.

LONDON ASSOCIATION OF ENGINEERS.—Saturday, November 1, 6.30 p.m., Charing Cross Hotel, W.C.2. "Making of Motion Picture Films," by Mr. F. N. Bush.

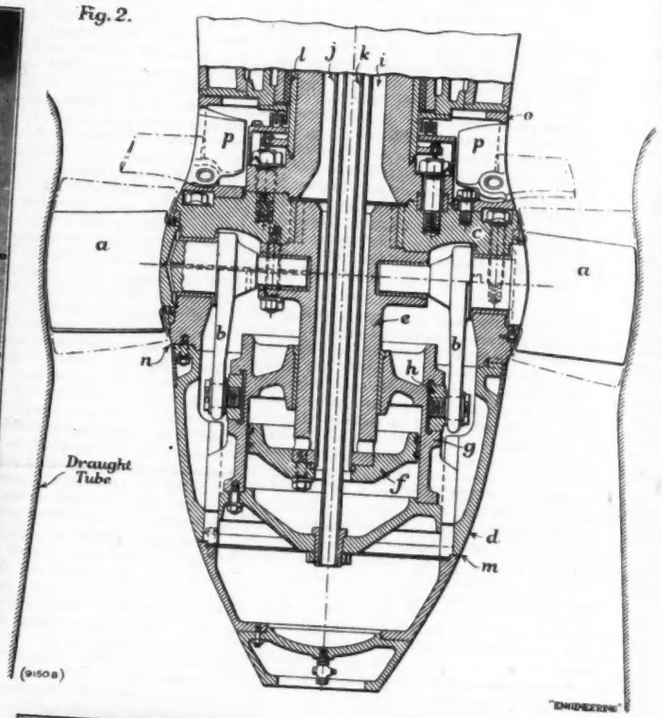
WATER-TURBINE RUNNER WITH FEATHERING BLADES AND HYDRO-BRAKE.

THE ENGLISH ELECTRIC COMPANY, LIMITED, LONDON.

(*For Description, see Page* 390.)

Fig. 1. Runner with Hydro-Brake Blades Open.

Fig. 2.



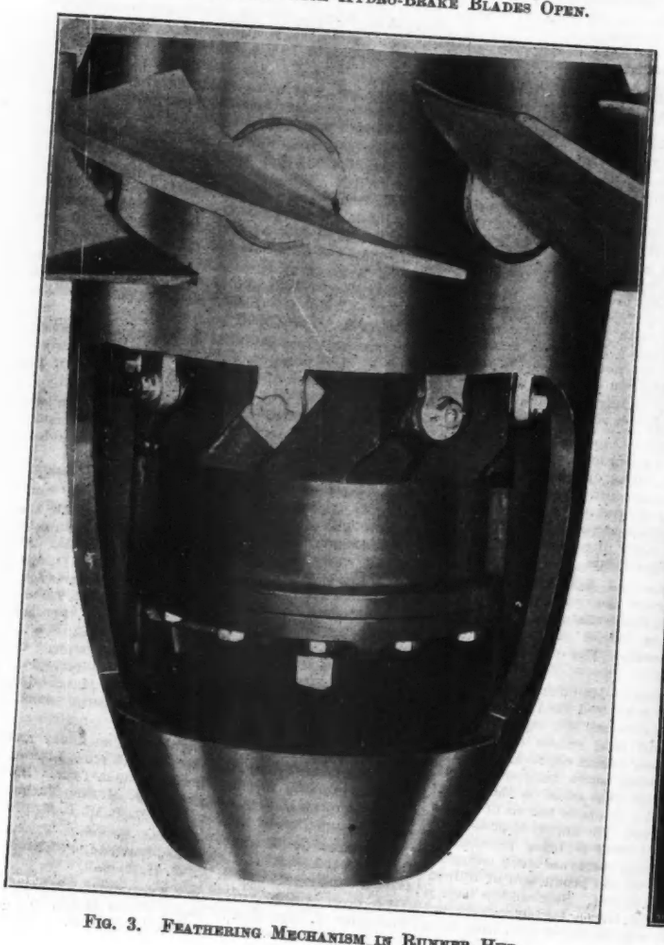


Fig. 3. Feathering Mechanism in Runner Hub.

Fig. 4. Runner with Hydro-Brake Blades Withdrawn.

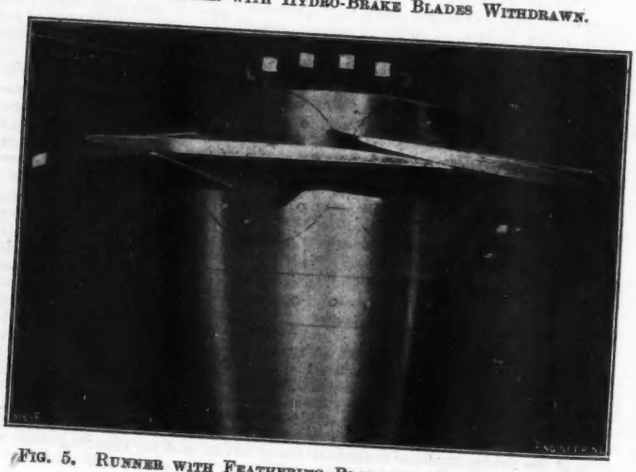


Fig. 5. Runner with Feathering Blades in Closed Position.

ENGINEERING.

35 & 36, BEDFORD STREET, STRAND, LONDON, W.C.2.

We desire to call the attention of our readers to the fact that the above is the address of our Registered Offices, and that no connection exists between this Journal and any other publication bearing a similar title.

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ADVERTISEMENT RATES.

Terms for displayed advertisements on the green art paper wrapper, on the inside black and white pages and in the buff art paper two-colour supplement, as well as for inserts, can be obtained on application to the Manager. The pages are 12 in. deep and 9 in. wide, divisible into four columns 2¼ in. wide. Serial advertisements will be inserted with all practicable regularity but absolute regularity cannot be guaranteed.

The charge for advertisements classified under the headings of "Appointments Open," "Situations Wanted," "Tenders," etc., is 8*s.* for the first four lines or under, and 2*s.* per line up to one inch. The line averages six words and when an advertisement measures an inch or more, the charge is 24*s.* per inch. If use is made of a box number the extra charge is 1*s.* per insertion, with the exception of advertisements appearing under "Situations Wanted." Series discounts for all classified advertisements can be obtained at the following rates:—5 per cent. for six; 12½ per cent. for thirteen; 25 per cent. for twenty-six; and 33⅓ per cent. for fifty-two insertions.

TIME FOR RECEIPT OF ADVERTISEMENTS.

Classified advertisements intended for insertion in the current week's issue must be received not later than first post Wednesday.

"Copy" instructions and alterations to standing advertisements for display announcements must be received at least 10 days previous to the date of publication, otherwise it may be impossible to submit proofs for approval.

The Proprietors will not hold themselves responsible for advertisers' blocks left in their possession for more than two years.

INDEX TO VOL. 163.

The Index to Vol. 163 of ENGINEERING (January-June, 1947) is now ready and will be sent to any reader, without charge and postage paid, on application being made to the Publisher. In order to reduce the consumption of paper, copies of the Index are being distributed only in response to such applications.

CONTENTS.

	PAGE
Emergency Repairs to Continental Ports (*Illus.*)	385
Literature.—Buckling of Webs in Deep Steel I-Girders. The Technology of Industrial Fire and Explosion Hazards. Air Conditioning and Elements of Refrigeration. Theory and Application of Mathieu Functions	387
Planck's Contribution to Physics	388
Some Aspects of Instrumentation	390
Feathering-Blade Water Turbine with Hydro-Brake (*Illus.*)	390
Temperature Indicator for Alternator Rotors (*Illus.*)	391
The Southern Railway Channel Steamer "Falaise" (*Illus.*)	393
Launches and Trial Trips	394
Royal Institution Lectures	394
Books Received	394
Personal	394
Notes from the North	395
Notes from South Yorkshire	395
Notes from the South-West	395
Notes from Cleveland and the Northern Counties	395
Notices of Meetings	395
London Water	397
The Classification of Radio Position-Finding Systems	398
Notes	399
Letters to the Editor.—The Fuel Economy Conference. Technological Qualifications. The Sub-Atmospheric Gas-Turbine Cycle (*Illus.*)	399
Obituary.—Sir Leonard Pearce, C.B.E.	400
Richard Sennett, F.R.S.N.A. (1847-1891) (*Illus.*)	400
Symposium on Internal Stresses	401
Launch of the Orient Liner "Orcades" (*Illus.*)	402
Maple Lodge Sewage-Disposal Works, Rickmansworth (*Illus.*)	403
Labour Notes	404
Street-Lighting Demonstration at Southport	405
X-Ray Examination of Butt Welds (*Illus.*)	405
Notes on New Books	407
"ENGINEERING" Patent Record (*Illus.*)	408

ENGINEERING

FRIDAY, OCTOBER 24, 1947.

VOL. 164. No. 4265.

LONDON WATER.

THE River Thames flows approximately along the centre line of the London Basin syncline, which it enters through the Goring Gap, eight miles north of Reading in Berkshire. The syncline is superimposed on an ancient Palæozoic platform, which is thought to be of anticlinal form. On this platform lie a series of deposits, many of wedge shape, laid down during the successive earth movements in the course of which the land was invaded by the waters of the sea and, from the west, by a hypothetical great river, the Eocene Amazon. The chalk, on which the London clay is superimposed and which is such an important geological feature of the region, is supposed to have been laid down in the clear water of a sea of great extent; the material may be traced across Europe, from Ireland to Russia. The present syncline basin is considered to have been formed in the Tertiary Era as a result of the great earth movements known as the Alpine Storm, which resulted in the raising of the Alps.

The main Alpine waves travelled from north to south, leaving east-west anticlines, but some geologists consider that the north-south course of the basin of the River Lee, and the Epping Forest ridge is evidence of secondary wave movements travelling westward. These geological events of long-past ages giving London the attractive series of hills by which it is surrounded, have created conditions in connection with water supply which are both of interest and importance. London appears to be where it is because the Romans built Londinium on the gravel-capped hills on which St. Paul's and the Bank of England now stand and which form eminences in the 50-ft. terrace on the north bank of the Thames. This was formed as a result of changes in the level of the land subsequent to the creation of the syncline basin. It is not possible to say how potable water was obtained in the early days, but in the Sixteenth Century it seems to have come mainly from wells within the city, although there was some additional supply through conduits presumably fed by some of the small rivers, such as the Fleet Brook and the Westbourne, which ran into the Thames. There was, however, a shortage of water at that time, and in 1609 the Corporation of London accepted Hugh Myddelton's offer to bring water from Hertfordshire by the construction of the New River. This engineering work, remarkable for its time, was completed in 1613. Modern practice is but an extension of that which existed in those early days, and last year the Metropolitan Water Board drew 65 per cent. of its supplies from the Thames, 18 per cent. from the Lee, and 17 per cent. from wells and minor sources.

The London Basin, from the water-supply point of view, constitutes a self-contained area which extends from the mouth of the Thames to Newbury in Berkshire and from the Chiltern Hills to the North Downs. The important water-bearing formations are the chalk and greensand. The former extends throughout the area, appearing at the surface in the Chilterns and the Downs. The greensand is less extensive, but is important from the water-bearing point of view. It is continuous on a line drawn from Hemel Hempstead to Staines, and from Maidstone to Haslemere, but in some parts of the basin is absent. The greensand is porous, but the water-bearing qualities of the chalk vary between different districts, depending on the extent to which it is fissured. These formations, in general, are imposed on impermeable beds and thus constitute underground reservoirs. The increasing population of outer London and the surrounding districts has resulted in continually growing demands on this underground water and, under present conditions, each outer area, to a major extent by means of wells, extracts water with no reference to the geology of the basin as a whole, or to the interests of its neighbours.

The proposals which have been put forward for the dispersal of part of the population of London by building or enlarging satellite towns will do nothing to assist in the solution of water-supply problems; Stevenage and Hemel Hempstead, for instance, both lie within the London Basin. The Water Act of 1945 empowers the Minister of Health to set up a Joint Advisory Water Committee for any area in which it may seem desirable, the Act being foreshadowed in a White Paper on National Water Policy. After study of this earlier document, the Metropolitan Water Board decided that a joint advisory committee would not be a suitable body to carry out a policy of unification in the London Basin, and prepared a scheme covering the creation of a single public authority to administer the whole of the Greater London water area. The details of this scheme were submitted to the Minister of Health, who, in November, 1946, appointed a Departmental Committee to examine the proposals. Brief particulars of the inquiry conducted by the committee are given in the Forty-Fourth Annual Report of the Board, which covers its proceedings in the year ended March 31, 1947. Joint opposition to the scheme was advanced by a body representing 28 local authorities and 29 water companies.

The Water Board's scheme proposes the co-ordination of water supply over an area extending from Baldock in the north to Horley in the south, and from Maidenhead in the west to Gravesend in the east. It would cover 2,754 square miles, which area is almost the same as that given in the Abercrombie Report for Greater London. Although the size and shape of the proposed water area are essentially determined by geological considerations, the boundaries, in some places, do not conform with those of the true water-supply area. The reason for this is that a strictly geological delimitation would cut across the areas of supply of some existing authorities, and would greatly enhance what must in any case be the difficult problem of reconciling and respecting the many existing local interests and rights. Some compromises were necessary, but, even with these, the proposed area represents geologically a great improvement on the existing arbitrary division of the water basin.

The Metropolitan Water Board at present consists of 66 members, who represent some 60 borough and district councils, six county councils, the

Corporations of London and Westminster, and the Thames and Lee Conservancies. Some members represent more than one authority. Although this may appear a somewhat unwieldy body, it operates entirely successfully in practice, but the conclusion cannot be drawn from this that an approximately similar authority, representing all the interests affected, would be equally satisfactory for the administration of the proposed greater water area. The majority of the members of the present Board are not directly concerned in water supply, but the enlarged area would take in districts served by 35 water boards or local authorities and 30 private companies, and would extend into three further counties. The Water Act of 1945 suggests the formation of a Joint Advisory Water Committee, but the Board consider that a more drastic revision of administrative arrangements is desirable.

The matter is dealt with in considerable detail in the latest annual report of the Board which gives an account of the various proposals put forward at the inquiry conducted by the Departmental Committee. The 28 local authorities and 29 water companies which opposed the Board's proposals, suggested that by suitable amalgamations the number of undertakers concerned could be reduced and that the activities of those remaining could be co-ordinated by the constitution of a series of joint advisory water committees for various parts of the London Basin. The work of these various committes would be co-ordinated by a Water Resources Authority, made up of representatives of each committee. The Water Board oppose this proposal, describing it as "cumbersome, tardy and expensive." Their own suggestion is the creation of a new authority to take over the activities of all existing bodies and administer the whole of the new area. It is added that "the transfers of the various undertakings should be effected on fair and reasonable terms," which is a very desirable clause at the present time.

On the constitution of the proposed new authority, the Board are less specific than seems desirable. It is stated that it should be non-profit-making and composed of public representatives, but its constitution "should be left either directly or indirectly in the hands of the local authorities." To say this is merely to burk the difficulties of a situation in which the interests of 177 local authorities are involved, these bodies greatly varying in legal powers and in the sizes of the areas which they represent. Until the conclusions of the Departmental Committee are known, speculation about the outcome of the whole matter is perhaps not called for, but in view of present trends in administrative policy it seems possible that water supply in the London Basin may be handed over to a Government-appointed body similar to the new electricity authority.

The alternative proposal put forward by the 28 local authorities and 29 water companies appears to be based on existing legislation. This, however, is framed to cover the water problems of the country as a whole and does not contain any provisions specifically designed to meet the problems of the London Basin. The Water Act, 1945, provides for the creation of a Central Advisory Water Committee and this body has been constituted. Their duty is to furnish information and guidance to the Minister of Health in connection with water problems. The Public Health Act, 1936, provided for the constitution of joint water boards and some extension of its provisions has been made in the new Act, which, among other things, provides that two or more water companies operating under a joint water board, if they are unwilling to amalgamate by agreement, may be compelled to do so by the Minister. As already mentioned, the Water Act, 1945, further provides for the setting up of Joint Advisory Water Committees for any area. Without going into further detail it will be clear that a complicated system of advisory and executive bodies has been set up, or at least has been made possible, which does not promise either the most efficient or the most economical administration of such a complicated area as the London Basin. The Metropolitan Water Board's proposal for an entirely new body with authority over the whole area, and presumably not subjected to control by any joint committee of any kind, is business-like and sensible.

THE CLASSIFICATION OF RADIO POSITION-FINDING SYSTEMS.

That considerable progress was made during the war in the associated fields of radiolocation and radio-communication is common knowledge, since it has been exhaustively described in the papers, which were presented to the two conventions held under the auspices of the Institution of Electrical Engineers in 1946 and in the spring of this year. Engineers generally have been able, therefore, to acquaint themselves with the developments which have taken place, while radio specialists have been provided with a mass of information which should serve as a basis for fresh advances. As is also well known, much of this work was carried out under conditions of both stress and secrecy. Inevitably, therefore, overlapping and loose ends occurred; and these defects are exhibited in the literature, and especially in the nomenclature, of the subject. To obtain full value from what has been done it follows that a good deal of editorial work is desirable, and that codification is also required if there is not to be confusion. It must, in fact, be quite clear that when different writers use the same terms they mean the same thing. This pitfall is not invariably avoided at present, while the coining of code names to confuse the enemy is now tending to general mystification.

Mr. C. E. Strong did well, therefore, to devote the address which, as chairman, he delivered to the Radio Section of the Institution of Electrical Engineers, on Wednesday, October 15, to a consideration of the best way of classifying radio systems as a whole. He began by postulating that "radio" is divisible into two branches, dealing with communication and location, respectively. By so doing, he gave radiolocation a different and wider application than has hitherto been usual, but this may be excused on the ground that it would be difficult to discover an equally succinct and comprehensive term for that purpose. He further noted that existing classification of radiolocation is inadequate or ill-defined. For instance, while "direction-finding" is used to define those parts of the field concerned with reception, there is no equivalent term for denoting the transmission of azimuth information; and while the term radar is all too freely used, its application should, strictly speaking, be confined to systems in which the objects detected do not actively co-operate. In fact, there is a lack of the wider terms of definition, with the result that the general has often to be described in the terms of the particular. To bring order out of partial chaos, radiolocation systems could be classified by their methods of application. This is already done in the radio-communication field, where the terms telegraphy, telephony, broadcasting and television are used as simple functional descriptions. Another way would be to distinguish them by the technical means employed in their operation, such as modulation or channel separation. A classification of this kind, however, is not sufficiently detailed for radiolocation purposes, since, as Mr. Strong points out, such systems as Gee and Decca, although closely related in function, employ pulses and continuous waves, respectively, and must, for that reason, be included in different categories.

It is therefore desirable to start with first principles and to observe that the position of an object on a particular hyperbola can be determined by measuring the difference of its distances from two fixed points; and that, similarly, its position on a particular ellipse can be determined by measuring the sum of the distances from those points. In fact, as Mr. Strong shows, all radiolocation systems are either hyperbolic or elliptic position line systems, the one being concerned with direction and the other with range. As, in practice, these distances are measured in terms of the time of wave propagation, it follows that all systems of radiolocation may be placed in one of two main categories, depending on whether they can be described as being "direction-determination" or "range-determination" systems. Direction-determination systems can, in turn, be divided into those used for "direction-giving" or "direction-finding," respectively, although the main methods in use can be employed for both purposes. The former, for instance, would include Gee, Decca, omni-range beacons, overlapping beam course beacons, and all systems transmitting azimuth information; while the latter would embrace the receiving counterparts of these methods. The next sub-division could be between broad-based and narrow-based systems, since there are considerable differences in the application of the two. Range determination and direction-finding systems also would have to be sub-divided into radar and non-radar groups. Further, those which do and do not require co-operation could be differentiated.

The segregation of the various systems on these broad lines is not, however, enough. Indeed, further separation according to the technical methods employed, in Mr. Strong's view, is essential. For instance, although both Gee and Decca are broad-based direction-giving systems and therefore fall into the same functional category, they employ widely differing technical methods. Carrying classification a step farther, it is therefore necessary to distinguish the various systems either according to the methods employed to mark the transmissions or according to the methods of modulation or channel separation employed. In the first case, the transmission is marked either by a succession of pips, as in Gee, while in the second, peaks and valleys of low-frequency sine-wave variation are impressed on the radio-frequency wave, as in the Benito ranging system. In the third, differences of distance are found in terms of the number of whole wavelengths and the fraction of wavelength by which one path is longer than another, as in direction-finding and omni-range beacons and in Decca. The main difference between these methods is that the first utilises pulses and, being discontinuous, is therefore inherently suitable for time-sharing methods of multiplex systems, and for time-discrimination between signals, while in the other two the transmission is continuous and the signals must be separated by using different frequencies.

If, however, modulation is used for classification purposes, a distinction must be made between systems which employ variable-amplitude and constant-amplitude methods. The latter, being akin to frequency modulation, is the fundamental form, as it is directly associated with variations in the time interval. In radiolocation, as distinct from radio-communication, modulation can only be effected by spacing the antennæ and may, therefore, be described as "space-modulation." Channel separation, however, can be effected by using frequency multiplex systems, in which the channels are separated by frequency; or by "time-sharing multiplex," in which they are separated by time. In Decca, for instance, the channels are kept distinct by separating their frequencies, while, in Gee, the transmissions from the spaced points are on the same frequency but, being in the form of interlaced pulse trains, are kept distinct by time-sharing. In fact, the signals pass through the same receiver, but do not interfere with each other owing to the separation in time. The same distinction may be made between pulse-phase and tone-phase comparison-ranging systems. In the first, simultaneous transmission and reception are possible on the same site, owing to the fact that the outgoing and incoming trains of pulses are interlaced in time; while, in the latter, the incoming and outgoing signals are on different frequencies.

The system of classification as outlined by Mr. Strong, therefore, differentiates in the first place between radio-communication and radiolocation, the latter term being expanded to include all methods of position determination, including direction-finding and radar. Radiolocation can then be divided into two categories, respectively, covering "range-determination" and "direction-determination," while these, in turn, can be sub-divided into broad-based and narrow-based systems. In "direction determination," too, a distinction can be drawn between direction-finding and direction-giving systems. A further differentiation can be made on the basis of the technical methods used. Mr. Strong modestly describes his suggestions as a preliminary reconnaissance. They will, however, arouse a great deal of interest; and will, we hope, lead to action along the lines he suggests.

NOTES.

THE KELVIN MEDAL.

IT has just been announced that the Kelvin Medal Award Committee, consisting of the Presidents of the Institutions of Civil, Mechanical, and Electrical Engineers, the Institution of Naval Architects, the Iron and Steel Institute, and the Institutions of Mining and Metallurgy, of Mining Engineers, and of Engineers and Shipbuilders in Scotland, have awarded the Kelvin Gold Medal for 1947 to Air Commodore F. G. Whittle, C.B., C.B.E. The award is in recognition of the eminent services Air Commodore Whittle has rendered to engineering science in those branches of engineering work with which Lord Kelvin was especially identified and to commemorate which the medal was instituted. The medal is presented triennially, and the last award was made in 1938 to Sir Joseph J. Thomson, O.M., F.R.S., no award having been made during the war years. The first recipient of the medal was Dr. W. C. Unwin, F.R.S., to whom it was awarded in 1920. The next to receive it was the United States scientist, Dr. Elihu Thomson, to whom it was presented in 1923. The medal for 1926 was awarded to Sir Charles A. Parsons, F.R.S., that for 1929 to Mr. André Blondel, of France, that for 1932 to the Marchese G. Marconi, and that for 1935 to Sir Ambrose Fleming, F.R.S.

MEAFORD POWER STATION.

The new Meaford power station of the North-West Midland Joint Electricity Authority, which is designed for a capacity of 120 MW, was officially opened on Monday, October 20. The site of this station, which is situated about 7 miles south of Stoke-on-Trent, is bounded by the London Midland and Scottish Railway and the Trent and Mersey Canal, and the whole of its output will be supplied to the grid. The generating plant consists of four 30-MW turbo-alternators, which are supplied with steam at a pressure of 600 lb. per square inch and a temperature of 825 deg. F., and generate three-phase current at 11·8 kV. Each alternator is connected to an outdoor transformer, which steps the voltage up to 132 kV. There are also 24 transformers with outputs ranging from 30 kVA to 5,000 kVA and voltage ratios of 11,000/3,000 volts or 3,000/400 volts, which supply the auxiliary plant and heating and lighting equipment. Stand-by power is obtained from a 3,000-kVA transformer, which is connected by a 33-kV line to a neighbouring substation on the authority's distribution network. The outdoor switching station is designed for 14 generator, feeder and coupler circuits, each of which is controlled by a 1,500-MVA oil circuit breaker and gang-operated isolating switches. The auxiliaries are controlled from a number of subsidiary boards. The motors installed for driving the auxiliaries number over 290, and have an aggregate horse-power of 16,300. The contract for the equipment of the station, with the exception of the boilers, cooling towers and cable work, was let to the General Electric Company, Limited, Magnet House, Kingsway, London, W.C.2.

THE WORLD'S SHIPBUILDING.

The gross tonnage of the merchant ships under construction in British shipyards continues to rise steadily, although, as is pointed out in Lloyd's Register Shipbuilding Returns for the quarter ended September 30, 1947, this progressive increase is necessarily influenced by the delays which present circumstances are imposing upon the completion of ships and the consequent prolongation of the time required for building them. The present total, namely, 2,112,669 tons, is greater, by 49,720 tons, than that for June 30 last, and is also greater, by 237,791 tons, than the aggregate for September 30, 1946. In fact, it has not been exceeded since March, 1922, when the total recorded was 2,235,998 tons. During the quarter under review the tonnage of shipping commenced was 275,762 and of that launched 302,209, while work has been suspended on only 2,036 tons. The present total of 2,112,669 tons is made up of 188 steamers, aggregating 976,758 tons; 260 motorships, totalling 1,125,507 tons; and 35 sailing ships and barges, making together 10,404 tons. The total gross tonnage of merchant vessels under construction abroad, on September 30, is given as 1,856,224, which is 72,517 tons greater than that recorded on June 30 last, when it was noted that no figures were included for Germany, Japan and Russia. These reservations still apply. The shipping commenced in overseas countries during the quarter under review amounted to 268,996 tons and that launched to 228,208 tons. The total of 1,856,224 tons for the ships being built abroad on September 30 is made up of 152 steamers aggregating 500,301 tons, and 567 motorships making, together, 1,355,923 tons. The leading shipbuilding countries overseas are Sweden, which is responsible for 294,345 tons; Holland, which is building 260,781 tons; France, with a tonnage of 257,046; Italy, with 227,037 tons; and the United States, with 177,669 tons. The total for the British Dominions is 189,905 tons, much of which is due to Canada, her figures being 142,600 tons. The vessels under construction in the world on September 30 included 34 steamers and 74 motorships, each of between 6,000 and 8,000 tons, 21 steamers and 61 motorships of between 8,000 and 10,000 tons, 27 steamers and 47 motorships of between 10,000 and 20,000 tons, and six steamers and two motorships of from 20,000 to 30,000 tons. The six steamers in the last category are being built in this country while, of the two motorships, one is under construction in Holland and the other in Sweden.

LONDON OMNIBUS SERVICES.

The task which has faced the London Passenger Transport Board since the war in maintaining adequate 'bus services was described by the chief mechanical engineer (road services), Mr. A. A. M. Durrant, C.B.E., M.I.Mech.E., at a Press conference on Friday, October 17. Mr. Durrant said that they had recently received the first 80 of the 3,000 'buses which had been ordered since the war; they expected to receive a further 80 before Christmas, and hoped to be receiving 100 a month by the end of 1948. Only 956 new 'buses were received during the war, compared with a pre-war average of 527 per annum. This resulted in a theoretical deficit of approximately 2,200, and to overcome this handicap, many 'buses were being retained in service for a greater number of years than was usual. The demand for spare parts had consequently increased, but the supply from manufacturers had simultaneously deteriorated. Mr. Durrant described the measures adopted to obtain spare parts. In particular, the oldest 'buses were scrapped, and the parts thus made available were used to keep other 'buses on the road—a system well known in the Army as "cannibalisation." More and heavier repair work was being undertaken in the Board's garages, and work was being decentralised from the main Chiswick works to the garages. Many parts were cast or fabricated, if spare parts were not available from the manufacturers. When there was a shortage of dynamos, some 'buses were sent out without this part, and charged batteries were dispatched periodically for use during the hours of darkness. About 5,000 'buses are used in the central area, and on one day recently 400 were off the road; the pre-war normal proportion out of service was about 7 per cent. Their difficulties had been accentuated by the increase in passenger traffic. The number travelling by 'bus each day had increased from 9,070,000 in 1938-39 to 10,160,000; and the average length of 'bus journeys had increased from 1·9 miles to 2·3 miles. Tram and trolley-'bus services had also been handicapped, but despite the difficulties the three services were now providing 23,000 vehicle-miles each day more than before the war.

LOANS FOR ELECTRICAL EQUIPMENT.—During the six months ended September 30, 1947, loans amounting to 54,178,079*l.* were sanctioned by the Electricity Commissioners to public authorities for plant, mains, buildings and other purposes connected with electricity supply. Of this total, 35,774,398*l.* was on account of plant and 10,460,552*l.* for buildings. No loan was granted to the Central Electricity Board in this period.

LETTERS TO THE EDITOR.

THE FUEL ECONOMY CONFERENCE.

TO THE EDITOR OF ENGINEERING.

SIR,—Your report of the recent Fuel Economy Conference of the World Power Conference at The Hague, on page 378, *ante*, contains the suggestion that the paper in Section C1, contributed by Monsieur P. Salmon, of France, "might well have been included in the special series of 'Reports on Fuel Economy since 1939'." This special series of 19 reports was published, not by the Netherlands National Committee (who published all the individual papers), but by the Central Office of the World Power Conference, as preparatory material for the Conference at The Hague. All were "collective" reports, prepared on behalf of the respective National Committees of the World Power Conference by an author or authors who remained anonymous, except in one instance, where the circumstances were unusual.

There was only one such special report from any one country. The French National Committee made an admirable contribution to the series, which was published by the Central Office in February, 1947, in French original and in full English translation.

Your readers will understand, therefore, why the paper by Monsieur Salmon could not have been included in the series of "Reports on Fuel Economy since 1939."

Yours faithfully,
C. H. GRAY,
Secretary, International Executive Council,
World Power Conference.
201-202, Grand-buildings,
Trafalgar-square,
London, W.C.2.
October 20, 1947.

TECHNOLOGICAL QUALIFICATIONS.

TO THE EDITOR OF ENGINEERING.

SIR,—As chairman of the sub-committee which was responsible for drawing up the Parliamentary and Scientific Committee's recent report on Colleges of Technology and Technological Man-Power, may I be permitted to make a few comments on your leading article of September 26, on page 301, *ante*? There were certain statements in that article which may possibly lead to misunderstandings among those who may not have or have had an opportunity to read this particular memorandum.

You stated that, although our Committee were careful to point out that any expansion of technology must not be made at the expense of needed developments in the arts, humanities, sociology and fundamental science, "it is plain that industrial application is considered to be a more paying proposition and therefore more desirable than the pursuit of scientific knowledge for its own sake." I do not think any such view was expressed in the Report, and certainly no emphasis was, as you later suggested, laid on such a view. I am also certain that the Committee would not agree to any document that expressed such a view.

You suggested, also, that our insistence on the predominant need for technologists was not upheld by the leaders of scientific thought. That need, however, was clearly expressed by the Barlow Committee. Only recently, too, Sir Henry Tizard stated that the real need in British industry was for men of scientific education who had the outlook of the engineer rather than that of a pure scientist; and that, owing to our comparative neglect of schools of technology of the first rank, they would not be forthcoming in sufficient numbers unless we greatly expanded and improved our schools of technology. In any event, it is surely not unreasonable that, in a Report dealing specifically with the question of technologists, we should seek to emphasise the importance of this particular deficiency to the general scientific well-being of this country.

You referred to a "recommendation, which may fall on some ears uncommonly like a threat, that the proposed National Council of Technology should

suggest broad lines for the national development and co-ordination of Higher Technological Studies in Universities." In paragraph 12, however, which deals with this matter, we only recommended that the Council should act in conjunction with the University Grants Committee, and that, if this course were adopted, progress should be possible along the lines in question. That, surely, is a very different proposal.

Again, you criticised the Committee "for emphasising the degree more than the justification for the degree"; but a close reading of the Report surely makes it clear that we only wished a degree to be awarded where justified.

Finally, you suggested that, while our Committee appeared to appreciate that changes would have to be made in some technological colleges to raise their courses to university standard, "the main concern is restricted to salary scales appropriate to highly qualified staffs." I do not think the passage which I have quoted is well founded, because, quite apart from the passages dealing with salary scales, there is a whole section of the Report dealing with the status of colleges of technology, and drawing attention, for instance, to the need for strong governing bodies. There are other references to this question throughout the Report.

Having made these few criticisms, however, I should like to say how glad I am that you have seen fit to draw the attention of your wide and influential circle of readers to this Report; but I would urge that, before anyone makes up his mind as to the soundness or otherwise of our proposals, he or she should obtain a copy from our office.

Yours faithfully,

W. T. Wells.

The Parliamentary and Scientific Committee,
6, Queen Anne's-gate,
London, S.W.1.
October 13, 1947.

THE SUB-ATMOSPHERIC GAS-TURBINE CYCLE.

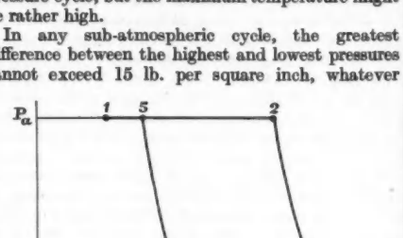
To the Editor of Engineering.

Sir,—Over twenty years ago Dr. T. B. Morley described the sub-atmospheric gas-turbine cycle in a paper presented to the Manchester Association of Engineers (*Transactions*, 1924-25, page 137), but in none of the numerous publications on gas turbines which have recently appeared has the present writer been able to find any mention of this cycle or any hint that it has been seriously considered. Although, at first sight, the sub-atmospheric cycle does not seem attractive, it may have certain advantages for marine use or for use on land when ample cooling water is available.

The diagram 1-2-3-4-5 relates to a simple form of open-cycle sub-atmospheric turbine. The point 1 refers to air in the combustion chamber, at atmospheric temperature and pressure. Constant-pressure combustion, at atmospheric pressure, takes place along the line 1-2; expansion in the turbine to a pressure below atmospheric along 2-3; constant-pressure cooling along 3-4; and re-compression to atmospheric pressure along 4-5, after which exhaust takes place to atmosphere. The lower pressure P_b is produced by an exhauster; the cooling 3-4 by a water cooler, or, perhaps, even by direct water injection. The work area 5-2-3-4 is of the same form as that applying to an ideal constant-pressure turbine working with the same overall pressure ratio and compressing air above atmospheric pressure, but the efficiency will be somewhat less since the points 5 and 1 do not coincide (the exhauster will discharge at a temperature greater than atmospheric) and the result of this is to increase the ratio of heat received to work done. However, windage losses for the exhauster may be less than for the compressor of the super-atmospheric cycle, since the exhauster blades are moving in a more rarefied atmosphere, and if both cycles were equally developed the difference in efficiency might not be too great. There would seem to be possibilities in a compound cycle utilising the exhaust heat from a piston engine either in a sub-atmospheric turbine, or in a turbine working partly above and partly below atmospheric pressure.

If sub-atmospheric working were applied to a closed-cycle machine with external heating, the working cycle would be 5-2-3-4, simply. A heat interchanger could be applied to transfer heat to the gas entering the main heating chamber at 5, from the low-pressure gas at 3, before the low-pressure gas passed through the water cooler. This cycle should be as efficient as any other constant pressure cycle, but the maximum temperature might be rather high.

In any sub-atmospheric cycle, the greatest difference between the highest and lowest pressures cannot exceed 15 lb. per square inch, whatever



the pressure ratio, and for this reason the cycle may, perhaps, find an application when it becomes possible, through the development of new heat-resisting materials, to employ greater expansion ratios and so to obtain higher efficiencies. It would be interesting to know whether the prospects of the sub-atmospheric cycle have ever been examined with a view to its future use with high pressure ratios and also whether any information exists with regard to the design of high-efficiency exhausters for service in gas-turbine power plants.

Yours faithfully,

L. Kastner.

Hawthornden,
Marple,
Cheshire.
October 11, 1947.

OBITUARY.

SIR LEONARD PEARCE, C.B.E.

We have learned with regret of the death, on October 20, of Sir Leonard Pearce, C.B.E., D.Sc., Engineer-in-Chief of the London Power Company since 1926 and previously chief electrical engineer of the Manchester Corporation Electricity Department. Sir Leonard, who was 74 years of age, was responsible for the construction or reconstruction of some of the most notable electric power stations in the country, including the Barton station at Manchester and the Deptford and Battersea stations in London. We hope to print a notice of his career in next week's issue of Engineering.

Building Exhibition.—The Minister of Works, Mr. Charles W. Key, M.P., will open the 21st biennial Building Exhibition, at Olympia, London, W.14, at 3 p.m., on Wednesday, November 19. The Exhibition will remain open until Thursday, December 4.

The Royal Aeronautical Society.—A branch of the Royal Aeronautical Society has been established at Preston, Lancashire. A programme of lectures has been drawn up, the next meeting taking place at 7 p.m. on Wednesday, October 29, when Mr. L. G. Burnard will speak on "Aircraft Production in War and Peace," in the Board Room of the Preston Chamber of Commerce, Fishergate, Preston. The President of the branch is Sir George H. Nelson, F.C.G.I., M.I.Mech.E., the chairman, Mr. W. E. W. Petter, B.A., F.R.Ae.S., and the honorary secretary Mr. D. B. Smith, O.B.E., B.A., A.M.I.Mech.E., A.F.R.Ae.S., The English Electric Company, Limited, Aircraft Division, Corporation-street, Preston, Lancashire.

RICHARD SENNETT, F.R.S.N.A. (1847-1891).

By Engineer Captain Edgar C. Smith, O.B.E., R.N.

Richard Sennett was the first naval engineer officer to be "Engineer-in-Chief" of the Navy, and he was also the youngest holder of that post, being but 40 when appointed. Of his two civilian predecessors, Thomas Lloyd was made "Engineer-in-Chief of the Navy" at the age of 57, and Sir James Wright was made "Engineer-in-Chief" at the age of 48. Sennett's immediate successors, Sir John Durston and Sir Henry Oram, were 42 and 49, respectively. Later Engineers-in-Chief have been somewhat older. From the time Sennett began his training in the "Steam Factory" at Devonport Dockyard as an "engineer boy," a name almost immediately altered to "engineer student," his great abilities attracted attention, and one of his fellow students, A. E. Seaton, wrote in 1921 that "Sennett was certainly our engineering and mathematical genius." His name is on the Roll of Honour of Devonport Dockyard School, he passed out of the Royal School of Naval Architecture and Marine Engineering at South Kensington as a first-class Fellow, and he was one of the three assistant engineers—T. A. Hearson and John Yeo being the others—who were fortunate enough to gain Whitworth Scholarships before the decree went forth that Admiralty-trained engineers were no longer to be considered eligible for these prizes; they had sufficient advantages already. Sennett's service career was as notable as his student career. When promoted from Engineer to Chief Engineer he passed over the heads of more than 300 of his brother officers, and at the age of 38 he made another bound forward, when he was given the rank of Inspector of Machinery Afloat.

The history of the early Admiralty training institutions, the Dockyard Schools, and the first and second Schools of Naval Architecture at Portsmouth, was fully told in Engineering in 1926 and 1929 by Sir Arthur Johns, while in 1923 a sketch of the South Kensington School was contributed by Sir William Smith. To the first and last of these institutions Sennett was much indebted, but he was destined to achieve distinction in any case. Born near Penzance, October 25, 1847, exactly a year after Durston was born at Plymouth, by open competition he became an engineer boy in May, 1862, and during the next four years had a thorough training in mechanical engineering as applied to ships, while attending the dockyard school for theoretical instruction. There was no similar system of training elsewhere in the country, and Sennett made full use of his opportunities. The number of youths so trained was not nearly sufficient to meet the needs of the rapidly growing Engineering Branch of the Navy and in the early '60s of last century the entries of assistant engineers from private yards and works far exceeded the number recruited from the Royal Dockyards; the respective numbers in 1861-62 being 163 and 23. Three events tended to alter this position; one being the raising of the standard of examination on entry, another the opening in 1864 of the school at South Kensington for clever and ambitious shipwright apprentices and engineer students, and the third the enlistment in 1868 into the service of fitters, smiths, boiler makers, etc., as Engine-Room Artificers to do the work hitherto performed by junior engineer officers and chief and leading stokers. For many of the junior engineers there was little hope of promotion to the higher ranks, and some of the chief and leading stokers were really capable mechanics. With the passage of years, the number of direct entries practically ceased and during the '70s and '80s naval engineer officers came almost exclusively from the student class. Sennett passed into South Kensington as a student in 1866 and passed out as an assistant engineer in 1870. During those four years he had had the privilege of studying the higher branches of the profession under Woolley, Merrifield, Cotterill, Unwin and other distinguished men of science.

His first appointment was to the Crocodile, one of H.M. Indian troopships, the only vessels in the

Navy which did any considerable amount of continuous steaming. In her he had experience with box boilers, fed with salt water and working at 30 lb. per square inch, and compound engines, a type around which raged a long and tangled controversy. The horizontal two-crank engine of the Crocodile, made by Humphrys and Tennant, had high-pressure cylinders placed behind the low-pressure cylinders. The engine was intended to develop about 4,000 h.p. Among other troubles there was abnormal cylinder wear, difficulty with the gudgeon bearings, and constant leakage from the cylinder jackets, formed of wrought iron plates and supplied with superheated steam. This was one of the Navy's first compound jobs and it surprised no one when the set was removed and replaced by a more reliable and better-understood simple-expansion engine. From duty in this troublesome ship Sennett was relieved in 1872 and appointed junior inspector under Wright, who had just been made Engineer-in-Chief; he never went to sea again. To his inspection duties were added, in 1873, those of lecturing on marine engineering at the newly-opened Royal Naval College, Greenwich. His next appointment came in 1875, when he returned to Devonport Dockyard as first assistant to the Chief Engineer, the redoubtable John Trickett, who was then much engaged on the work of the long-winded Boiler Committee of 1874. Included in Devonport's contribution to the Committee's investigation was the construction and operation of an experimental boiler working at the then high pressure of 55 lb. per square inch, of which details are to be found in the Committee's report, which runs to 1,400 closely-printed pages and weighs 14 lb. To-day, it is difficult to sort the wheat from the chaff in the report, but some little amusement can be obtained from the views expressed, and there are sidelights on several interesting personalities. Besides making boiler experiments, superintending repairs and trial trips, Sennett had the task of superintending the training of students and, in 1880, gave the first lectures in the new "Royal Naval Engineering College, Devonport"; a name given to the "Training School for Engineer Students" by the students themselves, but not officially recognised for 20 years. As Sennett says in the preface to his treatise, *The Marine Steam Engine*, published in 1882, the book was the outcome of his lectures at Greenwich and Keyham.

The appearance of this well-arranged and clearly-written text-book was most timely, for it gave naval engineers just what they wanted. It had a considerable influence on Sennett's career. He had dedicated it to Admiral the Right Hon. Sir Astley Cooper Key, G.C.B., F.R.S., who, 40 years before, had read Tredgold and de Pambour and had been largely responsible for the allocation of H.M.S. Marlborough at Portsmouth, and the building of Keyham College, for engineer students. Among others to whom Sennett presented copies was the engineer George Wightwick Rendel who, in 1882, severed his long partnership with Armstrong at Elswick to occupy a seat on the Board of Admiralty in the unusual role of "Extra Professional Civil Lord." There was little about warships and their machinery that Rendel did not know and he was the leading designer of hydraulic mountings for big guns. In a scrapbook of Sennett's, lent to me 25 years ago by his brother, Engineer Rear-Admiral Marrack Sennett, was a cutting from a Plymouth paper, the *Western Daily Mercury*, dated May 1, 1882, which ran: "*On dit* that a well-known and popular officer of the Engineering Department of Devonport Dockyard, and a successful author to boot, will shortly be required for important duties with 'My Lords.' Mr. Rendel is credited with a penchant for clever young men as his aides-de-camp and if his rumoured selection in this instance proves a fact he will not only be ably assisted but will be opening a wider field for the exercise of undoubted talent in the national interest." On the following day, May 2, Rendel wrote to Sennett from London, thanking him heartily for a copy of his book. Another probable recipient was Thomas Brassey, afterwards Lord Brassey, who compiled the monumental work *The British Navy*, 1882, my copy of which is inscribed "R. Sennett, Esq., R.N., from the author." All these individuals were members or officers of the Institution of Naval Architects, to which Sennett had contributed papers on compound engines. Considering all things, it is not surprising that, in the following year, 1883, Sennett found himself again at the Admiralty, this time as senior inspector; that, two years later, he received special promotion; or that, after another two years, he was made Engineer-in-Chief in succession to Wright.

Every period in naval engineering history is a record of experiment, transition and development. This was notably true of the period 1870 to 1890, and it is possible to trace the progress made by comparing the various editions of Sennett's book, as revised by himself and afterward by Sir Henry Oram. The introduction of box boilers, cylindrical boilers, water-tube boilers, the rise in steam pressures, the increase in piston speeds, the introduction of torpedoes and air compressors, the electric light, evaporating plant, hydraulic machinery, etc., are all referred to. Sennett's edition of 1882 contained the specification of a set of compound engines of 7,000 h.p., working with steam at 90 lb. pressure; his edition of 1885,

RICHARD SENNETT, F.R.S.N.A.

the specification of triple-expansion engines of 12,000 h.p., with steam at 130 lb. It was during his period of office that the triple-expansion engine was adopted for all ships. Every innovation brought its own problems and, with the new building programmes, the Engineering Branch was approaching a most difficult time. Why, after two years as Engineer-in-Chief, Sennett chose to give up rank and post and throw in his lot with Maudslay, Sons and Field, Limited, has not been revealed. Though of a family to which consumption had brought losses, he had been singularly active and enduring, but perhaps the strain was proving too great. Resigning in May, 1889, he became a director at Lambeth, only, however, to fall seriously ill in 1891. A voyage to the Cape led to no improvement, and he died at Walton-on-Thames on September 4, 1891, at the early age of 43. His retirement from the Navy had been regretted by all who knew him, and this found expression in a finely-illuminated address presented to him by the engineer officers of the Navy. After referring to their sense of loss at his severance of his connection with the Service, the address continued "They wish to take this opportunity of testifying to you their fullest appreciation of the many eminent professional and other qualities which have distinguished you through the whole of your career in H.M. Service; of the ability, tact and courtesy with which these qualities have always been exercised by you, which have tended so greatly to benefit the nation, to develop and elevate the Naval Engineering profession, and which have gained you the respect and admiration of the whole of the Engineer Officers of the Royal Navy." The address was signed by Engineer H. J. Walker, Chief Engineers W. W. Wootton and R. W. Edwards and Staff Engineers J. Rigler, F. Ford and W. J. Pettit.

SYMPOSIUM ON INTERNAL STRESSES.

WE gave, on page 375, *ante*, a brief report of the opening proceedings of the "Symposium on Internal Stresses in Metals and Alloys" organised by the Institute of Metals in association with six other leading scientific and technical societies and held at the Institution of Mechanical Engineers on Wednesday and Thursday, October 15 and 16. The symposium consists of 36 papers and these have been divided into sections, one of which was discussed at each of the four sessions of the meeting. The papers in each section were not presented by individual authors, but were summarised by a *rapporteur*, who also indicated those points on which he considered that discussion would be most profitable.

MEASUREMENT OF INTERNAL STRESSES.

The first session, on the morning of Wednesday, October 15, was held under the chairmanship of Dr. C. Sykes, F.R.S., and was devoted to the discussion of the five papers contained in section I, which dealt with the "Measurement of Internal Stresses." The *rapporteur*, Mr. D. A. Oliver, stated that the engineer usually encountered internal stresses in metals in the form of unwanted distortion during the finishing operations in the machine shop. Long components like gun barrels went out of straight or turbine rotors failed to run completely in balance, even when every care had been taken during the actual machining, such as finishing with light cuts. To the physicist and metallurgist internal stresses had an interest of a more fundamental character and arose whenever a metal was non-uniformly deformed in the plastic range. The obvious exception was when a pure metal was self-annealing at room temperature, in which conditions the internal stresses were rapidly relieved. An example of this somewhat unusual state of affairs was given by the behaviour of very pure aluminium, of upwards of 99·99 per cent. purity, which was self-annealing at room temperature. The normal engineering approach to the problem under discussion had been admirably summarised in the paper by Dr. Hugh Ford entitled "Mechanical Methods for the Measurement of Internal Stresses." Dr. Ford gave the methods adopted whereby an exactly known amount of material was removed from a component with corresponding observations of changes of dimensions. The paper covered the method adopted for cylindrical bodies, thin tubes, plates and flat bars. In the second paper of section I, the author, Mr. R. King, had given a careful survey of physical methods, other than mechanical or X-ray, which indicated at least qualitatively the influence of internal stresses, particularly for ferrous materials. The magnetic properties could be utilised in these cases and the author adequately outlined Becker and Kersten's approach to the problem. He rightly pointed out the restrictive assumptions as well as the supporting evidence.

Regarding electrical-resistivity measurements, many scattered facts were marshalled and the view expressed that resistivity methods might usefully be more often applied. Mention was also made of the newer magnetic-bridge testing comparators where differences could be observed, but where the indications were the result of many effects, such as hysteresis, permeability, frequency and resistivity. It was difficult to say just how reliable these methods, and those involving internal friction, could be for internal-stress determinations.

There were two papers dealing with the back-reflection technique for the measurement of stresses by X-rays. One of the authors, Mr. D. E. Thomas, showed how the lattice parameter could be deduced from the observed information, while Dr. W. A. Wood, in his paper, pointed out that the lattice strain was found to be a linear function of the applied body stress up to the macroscopic yield stress, after which plastic deformation set in and the lattice strain remained nearly constant. He concluded that in internal stress measurement close agreement must not be expected between the engineering and X-ray methods because the latter measured the resultants of the macro or body stress and the internal textural stress due to localised plastic flow. (Dr. Wood stated in his paper that the mechanical

methods of studying locked-up stresses measured only the macro effect). The last paper in section I, by Dr. H. Lipson, dealt with the complex subject of representing the data on imperfect crystals. The paper was not easy to summarise and might prove somewhat difficult reading to all except X-ray crystallographers. The author showed how the conception of the reciprocal lattice, whereby an individual plane was represented by a point in reciprocal lattice space, could be developed to show irregularities in planes by suitable extension of the reciprocal point into either a line, an area or a volume.

In the course of the discussion, Mr. S. Parkin asked for an indication of the accuracy to be expected in the determination of stress by sectioning or other mechanical method, because, as had been pointed out, the determination of relatively small amounts of strain on large test pieces was a difficult matter. He was concerned with steel strip which might be very highly and very irregularly stressed. Thus, band saws were treated by an individual known as a "saw doctor," who by entirely empirical methods stressed the saws so that, in use, they should maintain a straight blade and a straight cut. The treatment given was very significant in the life of a band saw and it was time an accurate method was introduced. Another speaker, Mr. D. O. Sproule, suggested that ultrasonics or supersonics might be used to reveal some of the internal stresses under discussion. A subsequent speaker, Mr. R. J. Brown, stated that it was methods of this type which were very necessary in the engineering industry since they were non-destructive and could be applied to the masses of steel with which the engineer dealt. The engineer was particularly interested because the fatigue properties of his components and assemblies were often greatly affected by residual stresses.

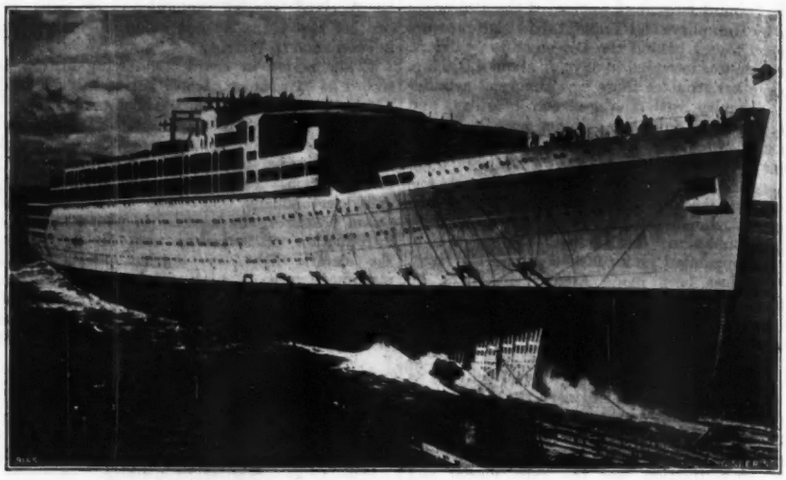
Mr. R. F. Tylecote said that one method of residual-stress measurement which had not been mentioned in the papers of section I was that of utilising strain-sensitive or brittle lacquer. This technique, however, could only be employed to measure surface stresses and directions. The next speaker, Mr. R. Weck, said that whereas the X-ray technique, as used for measuring internal stresses, could be learned in a number of laboratories, there were no such facilities for teaching mechanical methods. In fact, persons using mechanical stress-measuring methods had more or less to develop their own. A subsequent speaker, Mr. B. Sugarman, considered that one technique which would probably be worth trying was a combination of the photo-elastic and the brittle-lacquer methods. Professor E. E. Benson, who also contributed to the discussion, said that if an engineer desired to test, say, a turbine disc forging for internal stress, the X-ray method had so many limitations that it was hardly in the realm of practical politics, hence the method of cutting and measuring, which worked very well indeed when used in the proper manner, was that adopted.

Dr. H. Ford, in a brief reply, stated that Mr. Parkin had asked regarding the degree of accuracy obtained by mechanical methods. This depended on the method used, the stresses involved, the size of the specimen and other factors. It would seem that, in some methods, accuracies of $\pm$ 0·5 ton per square inch had been recorded in the normal stresses encountered, but, in other cases, the accuracies probably were only within some 30 per cent. or even 50 per cent. In this connection, he agreed with Mr. Weck that work was urgently needed on mechanical methods to obtain some idea of the accuracy attained and to compare various methods of measurement on specimens. He also agreed with Mr. Weck that a recognised technique, or techniques, should be worked out. The only other author to reply to the discussion was Dr. Lipson, who stated that he had made an honest attempt, in his paper, to describe the question of the reciprocal lattice for the benefit of metallurgists. Judging from Mr. Oliver's summary of his paper, however, he had not been particularly successful. He emphasised the importance of metallurgists and engineers understanding something of what X-ray crystallographers were doing, because it was evident from the papers contained in the symposium that X-ray methods were used in many circumstances in the industry.

(To be continued.)

LAUNCH OF THE ORIENT LINER "ORCADES."

MESSRS. VICKERS-ARMSTRONGS LIMITED, LONDON.



LAUNCH OF THE ORIENT LINER "ORCADES."

On Tuesday, October 14, the twin-screw passenger and cargo liner, S.S. Orcades, under construction for the Orient Steam Navigation Company, Limited, London, was launched from the Barrow shipyard of Messrs. Vickers-Armstrongs Limited, by Lady Morshead, wife of Lt.-Gen. Sir Leslie J. Morshead, K.C.B., Manager for the Orient Line in Sydney, and the accompanying illustration shows the ship almost at the end of her travel down the launching ways. This vessel, the third in the Orient fleet to bear the name Orcades, has been built to replace her predecessor, of 23,456 tons, which was sunk off the west coast of Africa in October, 1942. The new ship, christened with the name that was given to the Orkneys by the Romans, is intended for the carriage of passengers and mails, refrigerated and general cargo, between Britain and Australia, and she will accommodate 780 first-class passengers, an equal number of tourist-class passengers, and will carry a crew of 608. With a gross tonnage of about 31,000, the Orcades is the largest passenger liner yet built at Barrow, and she is also the largest ship to be launched by any country since the end of the recent war.

The power and speed of the new ship will also be greater than that of her predecessor, as the total shaft horse-power will be 42,500, to give a speed of 22½ knots, compared with the previous power and speed of 24,000 h.p. and 21 knots, and, due to the increased speed, her scheduled time for the voyage from London to Melbourne will be 28 days, instead of the pre-war time of 36 days. In general appearance, the Orcades will present a striking departure from the more usual profile for this type of vessel, as, immediately forward of the one large streamlined funnel there will be a superstructure comprising the officers' accommodation, the wireless rooms and the navigating bridge, surmounted by the single tripod mast, and forward of the main superstructure there will be a large open deck space for games, sheltered from head winds by a glass-fronted observation house.

The Orcades has an overall length of 711 ft., and the length between perpendiculars is 668 ft. Her moulded breadth is 90 ft. 6 in. and the loaded draught will be 31 ft. To meet the requirements of passenger accommodation in two classes, there are eight continuous decks, "A" to "H," and below "F" deck the vessel is subdivided into a series of watertight compartments by 12 transverse bulkheads. The continuous double bottom is divided longitudinally and transversely into separate compartments for fresh water, boiler feed water, oil fuel and water ballast, and a series of tanks arranged in the port and starboard sides up to "G" deck provides a complete double skin in way of the machinery spaces up to the water line. Electric welding has been employed extensively in the construction of the vessel. First-class passengers will be accommodated on "C," "D" and "E" decks, and part of "F" deck, in single- and two-berth cabins, of which a considerable number have private bathrooms, while the tourist passengers' accommodation, mainly in two- and four-berth cabins, is situated on "F," "G" and "H" decks. The first-class dining saloon, measuring 88 ft. by 72 ft., and seating 418 people, is on "F" deck, and the lounge, which is of considerable height and has a window area, is on "B" deck. To meet the varying climatic conditions, the ship will have an air-conditioning system which will be applied to the dining saloon, the restaurant and lounges, the library and hairdressing shops, and the inboard cabins on "D" and "E" decks. The open-air sports deck, already mentioned, is 64 ft. long by 68 ft. wide and is situated on "A" deck, forward of the main bridge house. Insulated cargo will be carried in Numbers 1, 2 and 3 holds, and the 'tween decks forward, which have a capacity of about 240,000 cub. ft., while Numbers 4, 5 and 6 lower holds, with a capacity of about 165,000 cub. ft., will be used for the carriage of general cargo. The cargo-handling equipment will consist of 5-ton derricks serving each hatch, with 10-ton and 20-ton derricks at certain hatches to deal with heavy lifts. A full complement of steel lifeboats, two being engine propelled, will be fitted under gravity-type davits, and a complete system of fire-alarm, detecting and extinguishing equipment will be installed for the passenger and cargo spaces of the vessel.

The main propelling machinery, which is also being constructed by Messrs. Vickers-Armstrongs Limited, at the Barrow works, consists of two sets of Parsons geared turbines, designed to develop 42,500 shaft horse-power, and supplied with steam by two large and two small Foster Wheeler water-tube boilers with controlled superheat. This provides for superheat from 850 deg. F. down to 600 deg. F. when manœuvring; the steam pressure at the superheater outlet will be 525 lb. per square inch. The boilers will burn oil fuel only, under forced and induced draught. The high-pressure ahead turbine is of the impulse-reaction type and its drive to the main gear-wheel is transmitted through double-reduction gearing. The intermediate-pressure ahead turbine is of the all-reaction type and the low-pressure ahead turbine is of the double-flow all-reaction type; the drive from both these turbines to the main wheel is through single-reduction gearing. The astern-turbine impulse wheels are incorporated in the intermediate- and low-pressure turbine casings, and are capable of developing 65 per cent. of the normal ahead power. Weir's regenerative condensers are fitted to each set of turbines, and the four-bladed propellers are of manganese bronze, the blades being cast solid with the boss.

In the course of the speeches which followed the launch, Sir Robert Micklem, C.B.E., R.N., Chairman of Vickers-Armstrongs Limited, mentioned the difficulties experienced in connection with materials and labour which had delayed the building of the Orcades, and said that the Orient Company had placed an order with his firm for another vessel of similar characteristics. The toast of the Commonwealth of Australia was proposed by Sir Alan G. Anderson, G.B.E., director of Messrs. Anderson, Green and Company, Limited, London, the managers of the Orient Company, and was replied to by the Rt. Hon. J. A. Beasley, P.C., High Commissioner for Australia, who emphasised the need for shipping to carry out the plans for the development of Australia. Mr. I. C. Geddes, Chairman of the Orient Steam Navigation Company, Limited, proposed the toast to the shipbuilders, and this was replied to by Sir Archibald Jamieson, K.B.E., C.B., Chairman of Vickers Limited.

MAPLE LODGE SEWAGE-DISPOSAL WORKS.

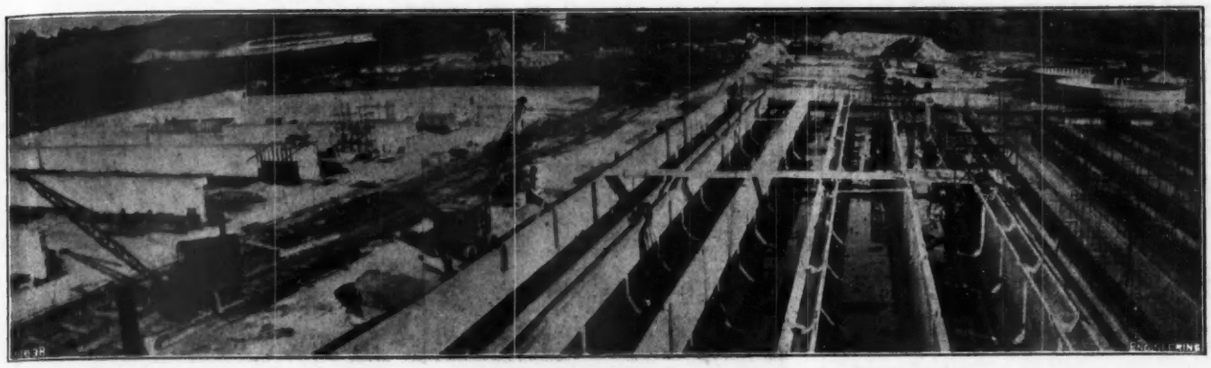
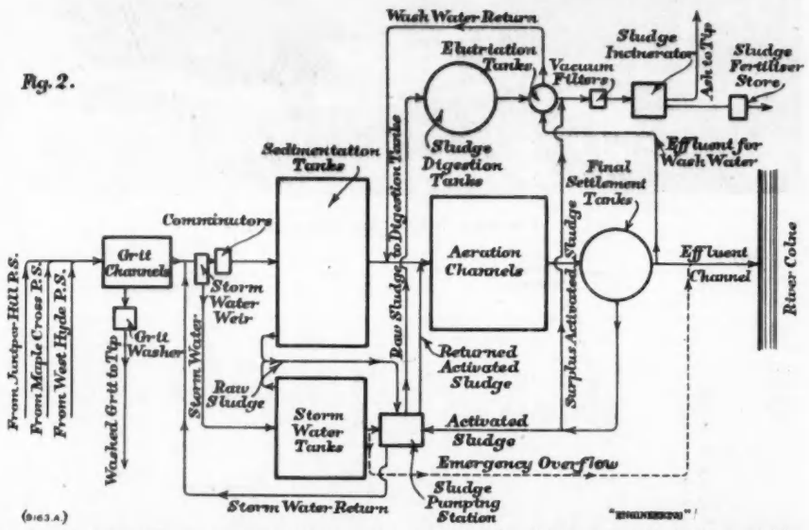


FIG. 1.

Fig. 2.



MAPLE LODGE SEWAGE-DISPOSAL WORKS, RICKMANSWORTH.

MAPLE LODGE sewage-disposal works, now under construction for the Colne Valley Sewerage Board, is situated at Maple Cross, about one and a half miles south-west of Rickmansworth, Hertfordshire, between the main road to Denham and a junction of the River Colne and the Grand Union Canal. The Board was constituted by Act of Parliament in 1937; work on the sewers was commenced on September 12, 1938, and the construction of drainage channels and an access road to the works was started in October of that year. Owing to the war, work was suspended late in 1940, and it was resumed on May 27, 1946. It is impossible ti give a reasonable estimate of the date of completion, owing to the shortage of materials and labour, but at the present time about 420 men and 80 prisoners-of-war are engaged on the site. At the invitation of the Board and the consulting engineers, Messrs. Sandford Fawcett and Partners, 53, Victoria-street, Westminster, London, S.W.1, we were able to visit the site, and see the progress made, on Wednesday, October 15, 1947. A photograph taken from the power house is reproduced in Fig. 1, on this page.

The works have been designed by the consulting engineers, to receive and treat, by the activated-sludge process, the sewage from an ultimate population of 430,000 to 450,000, and the design is based on a maximum rate of flow of 240 gallons per person per day. Wherever possible, the initial construction is to provide for a somewhat smaller population, but provision is made for additions at later dates. Eventually, the works will serve twelve local authorities, including those of St. Albans, Hemel Hempstead, Watford, Bushey, Chorleywood, Potters Bar, Rickmansworth, and considerable parts of adjoining rural districts. Twenty-four existing sewage-disposal works, and several sewage-pumping stations will be superseded. Some of the 45 miles of trunk sewers, the largest of which is 75 in. in diameter, have been laid, and others are under construction. The whole of the sewage will be pumped to the works, which occupy about 30 acres (although the Board own an additional 115 acres adjoining the works site). The main pumping station at Juniper Hill, about 1¼ miles north-east of Maple Lodge, will deal with about 90 per cent. of the flow; and two small stations at Maple Cross (adjacent to the works approach road) and West Hyde (about a mile north-west), will lift the Chorleywood and Misbourne Valley sewage. Fig. 2, on this page, is a diagram showing the system which will be employed at the works.

The whole of the power for the Maple Lodge works and the pumping stations will be generated in the main power house. The building is 200 ft. in length and 76 ft. in width; the carcase is almost complete, and the erection of the machinery has just been commenced. Power will be provided by five (ultimately six) engines, constructed by the National Gas and Oil Engine Company, Limited, which will operate on either oil, or methane gas produced by the digestion of the sewage sludge, and will drive a similar number of 750-kVA 3·3-kV alternators, constructed by Messrs. Crompton Parkinson, Limited. The normal rating of each engine is 660 brake horse-power, but when the supercharger is used the continuous rating is 750 brake horse-power, and the one-hour rating is 953 brake horse-power.

The exhaust gases from two of the engines which will normally run on methane, will be used to produce high-grade heat for heating the works buildings. Low-grade heat from the engine-cooling systems, at about 130 deg. F., will be used for the production of methane gas in the sludge digesters. Three (ultimately four) variable-speed centrifugal air-compressors, which will supply compressed air to the aeration channels, are being constructed by Messrs. Reavell and Company, Limited, and they will be driven by 3·3-kV 320-h.p. three-phase motors constructed by Messrs. Crompton Parkinson, Limited. The power house will also contain switchgear, a water-supply bore-hole pump, and panels which will automatically indicate the rates of flow, the plant running, the positions of valves, etc., at the three automatic pumping stations.

Four parabolic cross-section grit channels, in conjunction with Venturi flume outlets, giving a constant velocity at all rates of flow, will be constructed to receive the discharge from the mains. The grit will be discharged from the bottom of the channels, and will be washed in an elevated tank. The flow of sewage in excess of three times the dry-weather flow will be separated as it passes through the Venturi flume, and fed to the storm-water tanks. The normal flow of sewage will be passed through one or more of three comminutors. Four sedimentation tanks and three storm-water tanks, each 272 ft. long by 52 ft. wide, and with an average depth of 12 ft., are nearly completed, except at the inlet ends where the sludge hoppers will be situated. The tanks are shown on the left in Fig. 1. The present storm-water tanks will be used ultimately as sedimentation tanks, and a maximum of four more storm-water tanks may be constructed at a later date. The settled sewage will be passed to eight aeration tanks, which are shown under construction in the right-hand foreground of Fig. 1. Each tank consists of two "legs," each 308 ft. long, 15 ft. wide and 15 ft. deep. They will be constructed with ridge-and-furrow activated-sludge aeration tiles.

The mixed liquor from the aeration tanks will be passed to twelve (ultimately sixteen) final-settling tanks, which are shown under construction in the right-hand background of Fig. 1. Each tank is 60 ft. in diameter, with a coned floor at 30 deg., and a depth of water at the side of 8 ft. Hartley ring-type scrapers will be provided. The effluent from the final-settling tanks will be discharged over a weir into channels leading to the River Colne. The sludge-pumping station will contain eight electrically-driven pumps for handling the returned activated sludge, the raw primary and digested sludges, the works sewage, and the returned storm water. The basement and sumps are now under construction, and it has been necessary to enclose the area with steel sheet piles to exclude the large quantity of water which was flooding the sub-soil.

The sludge from the sedimentation tanks will be pumped to three primary-digestion tanks, each 76 ft. in diameter and 32 ft. deep, and heated by the cooling water from the power house. The digested sludge will be passed to an unheated storage tank of similar design. All four tanks will be fitted with floating gas holders and Dorr-Oliver stirrers, and the gas produced from the digesting sludge will be supplied to the engines in the power house. The sludge-disposal plant will be the first of its kind in this country. The Dorr-Oliver Company, Limited, are constructing the plant, and it was an associated firm of their parent company in the United States who first produced this type of plant. The digested sludge will be elutriated with effluent in two stages, in which the soluble salts produced during digestion will be washed out, and the effluent will be returned for treatment. The elutriated sludge and the surplus activated sludge will be conditioned with chlorinated copperas (produced by treating ferrous sulphate solution with chlorine gas), and filtered on Oliver drum vacuum filters. The resultant wet cake will be flash-dried in Raymond plants, and it is hoped to sell the granular dried sludge as a nitrogenous fertiliser. A system for detecting gas leakage will be installed at the works, which will give a suitable indication in the power house, sound an alarm, and, if necessary, actuate air valves for scouring the affected channels. The Juniper Hill pumping station will contain nine 27-h.p. pumps for dry-weather-flow, and four 75-h.p. storm-water pumps.

LABOUR NOTES.

The writer of the "Notes and Comments" in the October issue of *Man and Metal* regards it as encouraging that "more rapid progress may now be expected in the steel industry's coal to oil conversion progress." "The Government," he goes on to say, "has set the steel industry an annual production target, to be reached by the year 1951, of 15,000,000 ingot tons, and, with the completion of modernisation schemes and plant extensions at present in hand, there is no reason to doubt that the industry will be *technically* capable of achieving this target. On the other hand, however, it is doubtful, unless two extremely dangerous obstacles are removed, whether even the 14,000,000 tons that the industry has been asked to produce in 1948 will be forthcoming."

"The first of these obstacles," the writer of the notes says, "is the lack of urgency that is being shown in operating, to the full, the principles of the 48 hours continuous-week agreement. Unless continuous working is greatly extended in the very near future, the target figure is not likely to be reached. Nor will it be reached if there is a failure on the part of raw material supplies to fulfil the necessary requirements, and, in this respect, the pursuit of any course calculated to provide an alternative raw material and help lessen the industry's dependence on coal, has much to commend it. If, therefore, it is considered that further coal to oil conversion schemes beyond those already approved would materially assist the industry to hit the bull's-eye, none but the most serious objections should be allowed to stand in the way."

On October 1, the National Arbitration Tribunal issued its 1,000th award. Since its establishment in 1940, 1,174 cases have been referred to it, and some 11 per cent. were withdrawn, or otherwise disposed of, without the issue of an award. In the latest number of *Man and Metal*, the journal of the Iron and Steel Trades Confederation, the Tribunal is described as "an industrial safety valve—a final appeal court to which either side in industry can bring their differences, in the knowledge that they will be given a hearing and a decision by a body of skilled arbitrators and experts on the varied problems which arise in the relations between employers and workpeople."

Figures compiled by the Ministry of Labour and National Service, and issued by them last week, show that at September 18, the number of unemployed persons was 239,912, or about 1½ per cent. of the insured working population. Compared with the position a month earlier, there was a decrease of 9,779. Men and women unemployed for not more than two weeks increased by 9,304 to 64,421 since August 11. Persons employed in the export industries increased during August by 62,000, bringing the total up to 1,580,000. At the same time, there was a drop in the home-market labour force of 50,000, reducing the total to 5,486,000. The aggregate number of persons employed in industry increased during the month from 18,393,000 to 18,436,000. A continued decrease in the number of women employed reduced the total from 5,601,000 in July to 5,592,000 in August. The number of men in employment increased from 12,792,000 to 12,844,000.

On Wednesday last week, representatives of the Union of Post Office Workers discussed with Mr. Wilfred Paling, the Postmaster General, the claims of the union for increases of wages. The employees desire an increase of 1*l*. a week for postmen, counter staff, and certain other grades, a minimum wage of 5*l*. a week for all post office employees at the age of 21, and more rapid increments. Further consideration of the claims was adjourned for a fortnight.

Dealing with the target of cloth production set before the cotton industry by Sir Stafford Cripps, the quarterly report of the executive council of the Cardroom Workers Amalgamation declares that all concerned must take a full share in rejecting, or accepting, the suggested methods of accomplishing the task. The proposals included overtime and Saturday morning work, it is stated. During the war, overtime was worked to the extent of four hours a week, "but the position to-day is much more difficult." "The staggering of hours," the report goes on, "to avoid electricity peak loads, and the growing practice of balancing production by evening shift working, are measures to which the Amalgamation has assented, but which would militate against week-day overtime in many cases. And, knowing the value which members—particularly women—attached to the Saturday holiday, they could not contemplate a return to work on that day."

Re-deployment of labour, it is pointed out, is another suggested method by means of which the target might be reached, and surpassed. "This," the executive say, "is a vexed question, and it is high time it was studied objectively and its many forms thoroughly understood by the workers. Re-deployment has been practised in its empiric form for many years in our industry and its scientific counterpart is now developing and will, undoubtedly increase. The result of the Cotton Board experiment in scientific work-load assessment will shortly be available, and we shall then be in a better position to judge and decide on future policy. Meanwhile, other and, possibly, quicker methods of obtaining increased production may have to be experimented with and adopted, failing any substantial increase in the labour force."

At an informal meeting last week, representatives of the building-trades employers and representatives of the building-trades operatives, agreed to accept the wages proposal made to them by the Minister of Labour and National Service. Only the details were left to be adjusted by a meeting of the National Joint Industrial Council. The original claim of the unions was for an increase of 6*d*. an hour for craftsmen and one of 9*d*. an hour for labourers. Under the settlement, the operatives get an advance of 3*d*. an hour and accept a partial system of payment by results, calculated to increase their earnings by 20 per cent. over the basic rate.

The Docks Group of the Transport and General Workers' Union states in the organisation's *Record* for October, that, during recent weeks, there has been a substantial volume of employment in practically all the ports of the country. There have been occasions, the Group says, when to cope with the traffic—which is to some extent, "seasonal"—the labour force was insufficient to meet requirements, and the shortages could not be met by transferred labour from other ports. In these circumstances, local boards have had to consider the use of unregistered labour for a time. Generally, no difficulties have been experienced, although objections have been heard in one or two ports.

The Group "stresses" the point "that unregistered labour cannot be employed unless there is agreement on the local board," but it feels that "where such agreement is reached . . . the men should recognise their responsibility and loyally accept the decision of the local board which, after all, consists of 50 per cent. union representatives."

X-RAY EXAMINATION OF BUTT WELDS.

(*For Description, see Opposite Page.*)

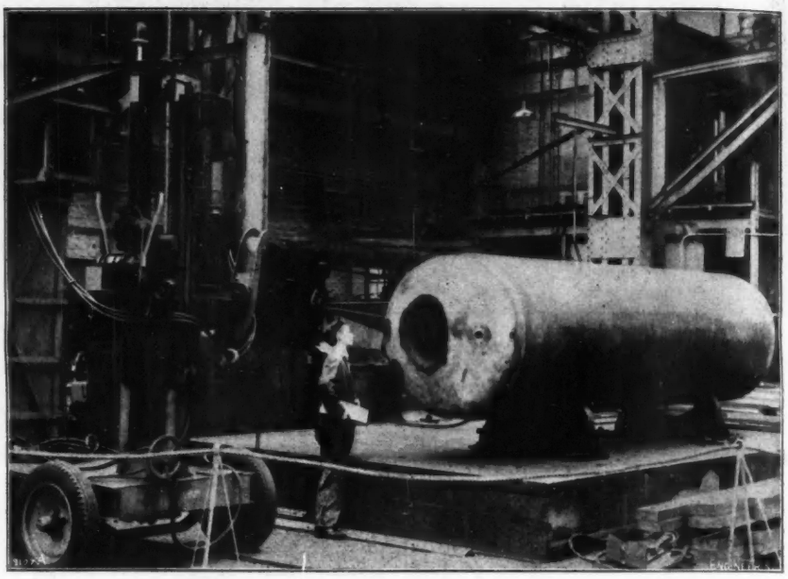
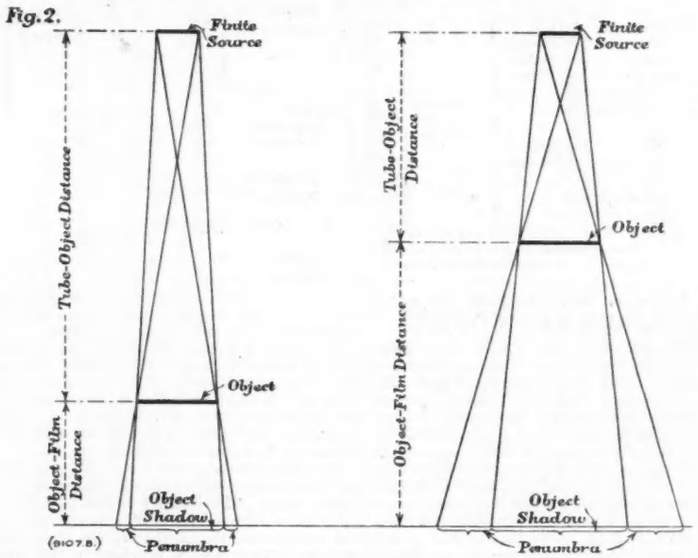


Fig. 1. Portable X-Ray Apparatus in Use.

Fig. 2.



EMERGENCY REPAIRS TO CONTINENTAL PORTS.

(*Continued from page* 338.)

ON September 12, 1944, ten days after the reconnaissance of Dieppe, a preliminary examination was made of the damage to the port of Ostend, a map of part of which is reproduced in Fig. 9, on this page. Blockships in the entrance channel constituted an effective obstruction, but the demolition of the quays was erratic. Some, especially in the Port de Pêche and the Bassin à Marée, were thoroughly ruined, so as to preclude the possibility of short-term repairs; others had been prepared for demolition, but the charges had either not been fired or had failed to explode. Attention was directed, therefore, to the reinstatement of the quays which were in reasonable condition, the provision of access roads, and the removal of German fortifications, while the Royal Navy undertook minesweeping and the removal of blockships. Coasters were able to berth by September 26, tankers by September 29, and by October 14 the port was dealing with a daily average of 2,000 tons of stores. The civilian authorities co-operated willingly, their work accounting for 367,000 man-hours, compared with 248,000 military man-hours. Much of this work was expended on maintenance that had been neglected during enemy occupation.

The first tasks undertaken, therefore, were clearance of mines and demolition charges (laid along quays, and in the form of minefields), clearance of debris and underwater obstructions, filling in bomb craters, providing access roads, restoring quay surfaces, and removing German fortifications. This work was carried out chiefly on and around the quays on the west side of the Avant Port, *i.e.*, the Vieux Quai, Quai Istanbul, Quai Gare Maritime, and the Quai des Paquebots, and in the Nouvel Avant Port at the north-west end of the Quai de Marée. Three concrete ramps for L.S.T. (tank-landing ships) were constructed; work on the first, which was located on the west end of the filling in the old lock entrance to the Port de Pêche, was started on September 18, and the first ship discharged on October 5. The surface of the exit areas and roads was subsequently improved. It was found that ships damaged this L.S.T. ramp by approaching it at an angle. This was due to the angle of the timber training jetty on the port side, the jetty being erroneously used as a guide by approaching vessels. The experience gained on this site emphasised the importance of a simple square layout for such ramps. The second ramp was built on the south quay of the Bassin d'Échouage, by removing masonry on a slope, and concreting the surface and the area at the head of the ramp. The site chosen for the third ramp was on the north-west corner of the artificial island at the entrance to the Bassin de la Marine. A V-trestle bridge on "camels' feet" at 10-ft. centres was built over the lock entrance to provide an exit road for discharged vehicles, and all this work was completed by October 31.

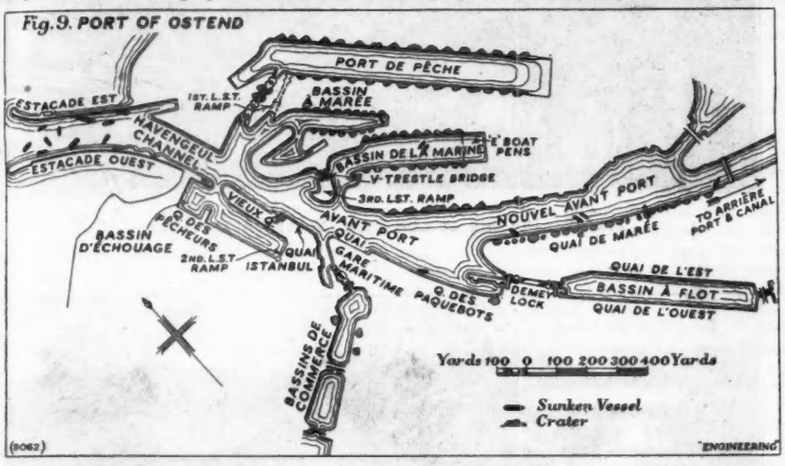
The length of quay along the north-east side of the Nouvel Avant Port had been thoroughly demolished except for a short length of about 100 ft., as shown in Fig. 10, on this page. It was not possible to repair it, but moorings were constructed in the form of four timber dolphins, one of which is shown in Fig. 12, on page 386, set clear of the wrecked quay and approached therefrom on a light timber cat-walk. Each dolphin consisted of a cluster of nine timber piles driven with one in the centre and eight spaced round it on a circle of 10-ft. radius; the upper ends were then drawn together and lashed with steel-wire rope. The short length of comparatively sound quay was used for mooring a pontoon, 86 ft. by 43 ft., which the Army provided for the use of the Royal Navy for oiling small craft.

The work carried out at the Quai de Marée in the Nouvel Avant Port included underwater clearance and repairs to the quay. Three cranes and a boiler which had been blasted into the water were cleared, and some assistance was given to the Royal Navy by undertaking a search for mines on the harbour bottom, for 50 ft. out and along the entire length of the quay. A shed had been found stocked with mines of a type which had a large base, and a single prong, standing up about 3 ft., which would be exploded by ships subsiding at low water. It was suspected, therefore, that some of these had been laid on the harbour bottom, but none was found. The principal danger to divers arose from underwater explosions at the harbour entrance in connection with wreck dispersal and counter-mining. A heavy deposit of soft mud also hindered the divers, one of them sinking over his helmet on several occasions. The Quai de Marée had been prepared for demolition by placing charges at about 100-ft. centres, 12 ft. from the edge of the quay. The craters formed were about 50 ft. in diameter and 8 ft. 6 in. in depth, although nearly half of the charges had not exploded. Each demolition charge consisted of two drums, 2 ft. in diameter and 3 ft. long, filled with explosive and placed vertically, one on top of the other; they were placed in a prepared pit, 8 ft. in depth and 2 ft. 6 in. in diameter, with a concrete cover. A friction igniter with a 7- to 9-minute fuse was incorporated in the upper drum. The craters were repaired by rebuilding the quay wall in brick and concrete, filling in with rubble, and repairing with granite sets or concrete. Thus, the whole length of the Quai de Marée—2,500 ft.—became available for deep-water berths. The south-east end of the quay is shown in Fig. 13, on page 386. It was used mainly for discharging tankers, a pipe-line constructed round the Arrière Port enabling them to discharge directly into barges in the canal basin.

In December 1944, it was decided to use the tidal, but sheltered, berths in the Bassin de la Marine, for small naval and R.A.F. craft. The craters in the east quay were repaired and the surface paved for a width of 25 ft. and a length of 600 ft. at the southern end, and two new access roads were built. The restored quay is shown in Fig. 14, on page 386. Underwater obstructions were removed, and two new timber stages, each 30 ft. long and projecting 18 ft. 6 in. from the rebuilt quay, were constructed on existing timber piles. The stages were joined, and extended on both sides for a total length of 250 ft., by a walk-way 6 ft. 6 in. wide, also built on existing piles. North-west of this timber wharf, and just off the east quay, four pile-cluster dolphins were driven as moorings, allowing 6 ft. 6 in. draught at low-water level. The dolphins, which were located clear of the submerged rubble of the demolished quay, are shown in Fig. 14.

The state and possible use of the non-tidal basins had been given early consideration. The Port de Pêche was too badly damaged for short-term reinstatement, the locks being wrecked and obstructed by blockships and the quays thoroughly ruined, as already noted. The locks to the Bassins de Commerce were blocked by a sunken barge and obstructed by a demolished bridge, but the gates and operating gear were in good order. The locks were soon cleared and the docks subsequently used by the Ostend fishing fleet. The quays and cranes of the Bassin à Flot were intact, although mined for demolition; but the Demey lock leading into it was blocked by two sunken hopper vessels which fouled the gates. They had been sunk by blowing large holes in the sides of the hopper sections. The entrance to the lock was also obstructed by a demolished swing-bridge, shown in Fig. 11, on page 386. This was typical of the German method of demolishing a swing-bridge; the pivot was blown out, leaving a cumbersome mass of steelwork.

Fig. 9. PORT OF OSTEND



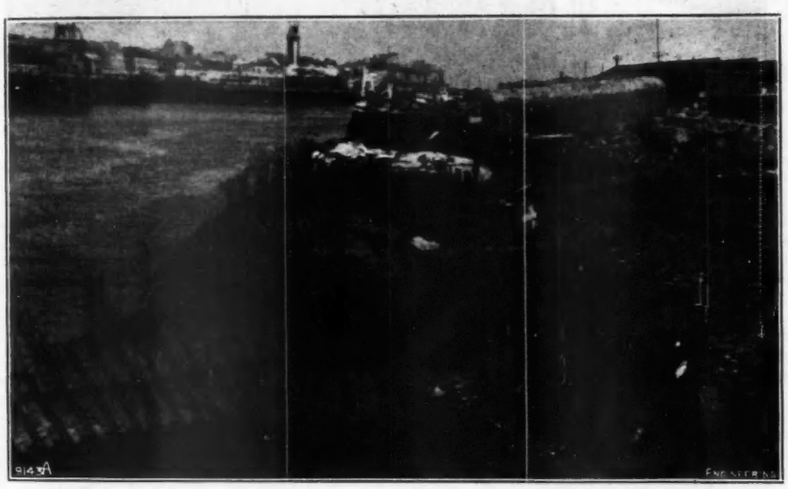


FIG. 10. DEMOLISHED NORTH-EAST QUAY, NOUVEL AVANT PORT.

EMERGENCY WAR-DAMAGE REPAIR WORK AT OSTEND.

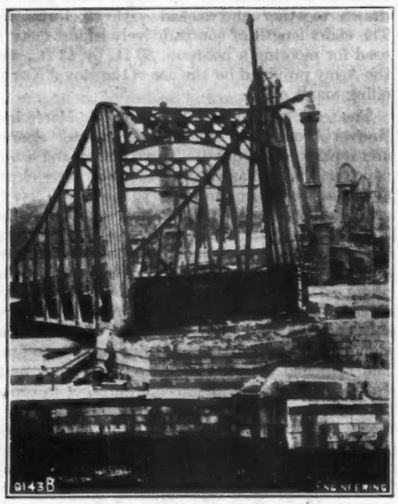


Fig. 11. Demolished Swing Bridge.

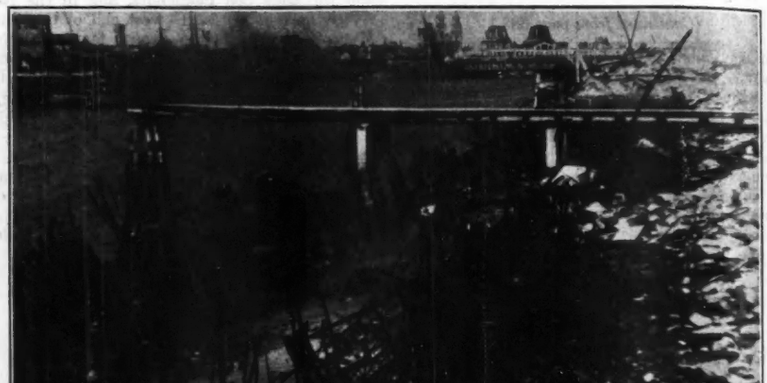


Fig. 12. Dolphin at Low Tide, Nouvel Avant Port.

Several methods of clearing the wreckage of the sunken vessels were considered, but rejected for various reasons. Patching the sides of the hoppers under water as a means of floating the ships was too formidable a task; and it was not possible to use explosives in the confined space of the lock without causing undesirable damage. Serious consideration was given to a scheme for draining the lock by pumping, carrying out emergency repairs to the exposed wrecks, and then floating them away; but an examination of the design and condition of the lock floor indicated that it would not be safe, owing to the possibility of the floor lifting due to the head of water. It was finally decided to lift the wrecks with 80-ton camels which the Royal Navy brought over from the United Kingdom. Military personnel cut up the swing bridge and lifted the pieces clear with a 50-ton floating sheerlegs. This permitted the sheerlegs to be floated through the flood gates to the outer side of the ebb gates, where they were used for lifting the camels over the ebb gates, to a position where the camels were able to lift the wrecks. Army divers succeeded in passing lifting ropes under the wrecks which lay on the lock floor. The wrecks were then raised and moved clear of the outer gates, which were opened to allow them to be moved away. A Diesel generator-set was installed for operating the gates, and the whole job, which had been started on September 20, was completed by October 30.

The brick-built roundhead on the south side of the entrance to the Bassin d'Échouage had slipped forward about 1 ft. 6 in. in 1937, and in November, 1944, a vessel collided with the wall, causing further damage. It was therefore decided to cut down the 8-ft. thick brick wall to high-water level, and rebuild it with a 5-ft. wall of concrete faced with bricks. The fill behind the wall had been excavated, in 1937, to a depth of about 10 ft. below the top of the wall to reduce the pressure, and this arrangement was continued. Two V-trestle camel-foot wharves were constructed in the Bruges-Ostend canal for unloading barges, one 300 ft. in length and 25 ft. wide for inland water transport, and the other, 30 ft. long and the same width, for the use of the Royal Air Force.

While repairs were in hand at Ostend a ship was mined, and a fire and a collision caused further damage which had to be rectified. The ammunition ship Cedarwood struck a mine off the Quai Istanbul and sank, with its cargo unharmed, on October 2, 1944. Royal Engineer divers salved all the ammunition, and the vessel was subsequently re-floated by the Royal Navy. On February 14, 1945, a fire occurred among small craft, principally motor torpedo boats, in the harbour, and the drift-

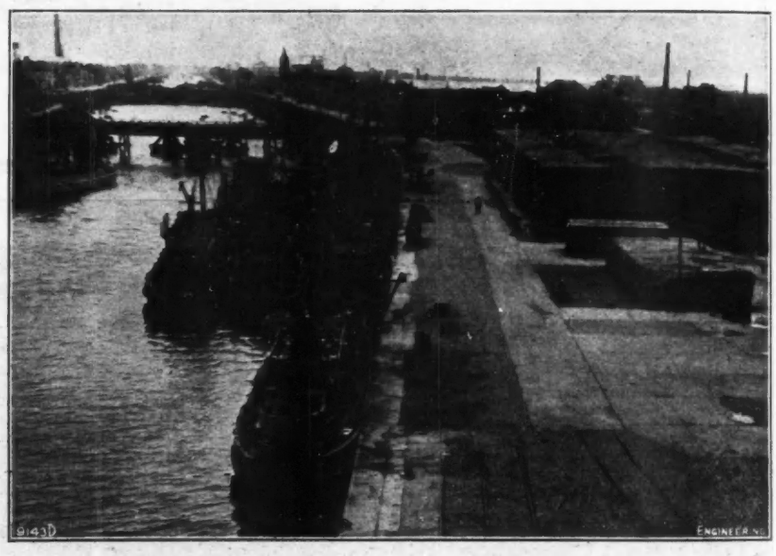


Fig. 13. Quai de Marée; Arrière Port and Canal Beyond.

Fig. 14. Dolphins and Restored Quay, Bassin de la Marine.

ing burning vessels caused damage to the timbers of the jetties at the entrance to the Bassin de Commerce and to the training jetties of the L.S.T. ramp in the Avant Port. Damage was also done to certain shore establishments by explosions which occurred in some of the craft. The condition of the east entrance jetty (Estacade Est), early in 1945, was unsatisfactory. It had been neglected during the war years, the winter gales had caused some damage, and the use of explosives for clearing the blockships in the entrance channel had naturally also affected the jetties. Thus, when a vessel collided with the east jetty and wrecked a length of about 200 ft. in March, 1945, it became imperative to carry out repairs immediately, to prevent complete disintegration of the jetty. It involved something more, however, than the short-term repairs to which the Army were both suited and accustomed, and as the civilian authorities declared themselves willing and able to undertake the work, this course was adopted. The Royal Engineers, however, provided the necessary materials.

The foregoing account covers the principal works carried out by the Army and civilians in the port of Ostend. Throughout the whole period much effort was expended on the construction of temporary roads and paved areas, and on the maintenance of existing roads and quays. With the capture of Antwerp on September 4, however, the military importance of Ostend port decreased, and it was subsequently used for discharging tankers, disembarking reinforcements, and evacuating casualties in hospital ships. It also served as a base for light naval and R.A.F. craft, and, on completion of the ramps, for discharging tank-landing ships.

(To be continued.)

LITERATURE.

Buckling of Webs in Deep Steel I-Girders. By Professor Georg Wästlund and Sten G. A. Bergman. Translated by I. Cyon. A.B. Tidskriften Byggmästaren, Stockholm. [Price 6 kr.]

This lucid and readable report includes not only an exhaustive critical review of the existing literature on its subject and an account of extensive original experimental work carried out at the Institute of Structural Engineering and Bridge Building of the Royal Institute of Technology, Stockholm, but also some carefully reasoned proposals which are directly applicable to practical design.

The experimental work consisted in applying shearing loads and bending moments, separately and in combination, to eleven full-sized welded specimens, covering a range of side-ratios and web thicknesses. Measurements of the deformations perpendicular to the plane of the web were made at numerous positions and contour diagrams plotted at various loads; load-deformation diagrams for closely spaced points in the plane of the web are given. Surface strains were measured in four directions by means of Huggenberger extensometers, and the overall deflections of some of the specimens were measured. The webs were coated with dilute plaster of Paris to reveal Lüders lines and other yield phenomena. The results are presented by means of clear diagrams on which the computed critical loads, according to several theoretical investigators, are also indicated.

Although the report does not claim to produce anything very novel in the way of results, it confirms a number of features which, hitherto, have been rather inconclusively established. Prominent among these features is the observation that the "critical buckling load" of the web has little significance in relation to the load-bearing capacity of the panel, since considerable buckling can occur in thin webs before permanent damage is done. Further, while the buckling is usually considered as an elastic instability phenomenon in most theoretical works, it is fundamentally different from the buckling of a strut, inasmuch as it occurs gradually and does not lead directly to collapse. The explanation offered for this, amounts, in effect, to the suggestion that, while the panel may buckle in the direction of the compression diagonal, the load is simply transferred to the tension diagonal, and, at the same time, the buckling gives rise to membrane stresses which tend to inhibit further buckling. It is also brought out that these membrane stresses produce bending of the "frame" in the plane of the panel, pointing to the importance of the flexural rigidity of the "frame" as a factor in the shear strength.

The discussion of the various theoretical treatments which have been proposed is competently handled, without abstruse mathematics. In particular, the inadequacy of the linear theory of plates, due to the fact that its fundamental assumptions cannot be realised in practice, is clearly established. This applies chiefly to the assumption that the plate is initially perfectly plane, and to the collateral condition that the deflections perpendicular to the plane are small in comparison with the thickness. Because of these assumptions, the linear theory of plates cannot take account of membrane stresses, which are shown by experiment to play an important role, greatly affecting the character of the buckling phenomenon. It is also shown that the non-linear theory, while probably adequate to describe the phenomenon, is excessively intricate for application to most practical cases. Evidently, the experimental approach is likely to be more promising than the theoretical approach, and the work described in the report is an important contribution in this respect. The effects of initial lateral deflections of the web plates were investigated in the case of one specimen, and were found to be surprisingly small.

It is unfortunate, perhaps, that more modern strain-gauge technique, using, for example, the electric resistance or short-base acoustic types of gauges, was not available for this work, to enable a more complete description of the stress-patterns to be given, and that modern brittle lacquers could not have been used instead of the plaster of Paris. It must be remembered, however, that both stress-patterns and brittle lacquers can be very misleading in this particular field of investigation unless the difficulties in their interpretation are fully appreciated. The translation from the original Swedish into English, by Mr. I. Cyon, is well done; and, although some slightly unfamiliar nomenclature is used sometimes, it has been clearly defined, so that no ambiguity results.

The Technology of Industrial Fire and Explosion Hazards. By R. C. Smart, A.M.I.Mech.E. In two volumes. Chapman and Hall, Limited, 37, Essex-street, London, W.C.2. [Price 16*s.* net each.]

This work treats of the materials and processes in industry with which a fire or explosion hazard exists, with the accepted precautions to be taken against such risks, and the methods of extinguishing any fires which may occur. The first chapter, in which Mr. Smart lists the authorities and others interested in the study of fire prevention, is particularly valuable and it is to be hoped that his analysis of the present position may lead to a unification of authority and the codification of precautions, so that general practice may be brought up to the standard imposed by the more progressive firms. The book would have been improved, however, if the discussion of flameproof motors, on page 147, had been expanded to detail the valuable work carried out by the Safety in Mines Research Board, at Sheffield. The chapter on toxic gases is notable for the lack of any reference to mercury vapour; and the danger of pneumonia following exposure to ammonia might have been mentioned. The chapter on lightning hazards is useful, but would be still better if it included some reference to recent American work. It is generally accepted, incidentally, that the function of lightning conductors is principally to guard against direct strokes by the readjustment of the potential gradient near the building by a continuous discharge from ground to air.

It is to be regretted that, in his discussion of the hazards associated with electrostatic charges, Mr. Smart follows the approach all too common in writings on this subject. After a general statement on the generation of charge by rubbing, he describes some of the more serious accidents which have been ascribed to this cause and offers earthing as a panacea; he ascribes incendive power to the current passing in a spark. Evidence is fairly conclusive that, for capacitance sparks, the critical quantity is the electrical energy dissipated. While only materials of high insulation resistance can develop charges, they are, by the same property, incapable in themselves of providing an incendive spark. It is the conductors associated with a process, particularly the operators, which provide carriers of free charges and paths for the spark discharges. Good earthing of all conductors thus offers safety, but it cannot be over-emphasised that any earthing programme must be complete; a plant in which some conductors are earthed while others are left insulated will be more dangerous than in its original condition. Charges are not dissipated through moist air, as the author states, but through the conducting films formed on walls, fabrics, etc. There is a lag in the reaching of equilibrium conditions which must be allowed for if moist air or injected steam is relied upon for charge dissipation.

In his treatment of fire-fighting methods, CO_2 foams are hardly given the prominence that they deserve. The book appears, from internal evidence, to have been written about 1943, and some allusions to air-raid precautions, bombs, etc., might well have been edited somewhat in the light of later events. Though mention is made of various other publications, very few full references are given; page and volume are hardly ever quoted, while in many cases investigators are cited without any reference at all. It will be gathered from these comments that, while there is much in the book that is useful, it offers scope for a certain amount of revision. If a subsequent edition is called for, we would suggest the advisability of issuing it in a single volume, the size and the price of which could be reduced by omitting the details of physical and chemical data for industrial materials and of manufacturing processes, which are not strictly relevant to the discussion of fire hazards.

Air Conditioning and Elements of Refrigeration. By Samuel P. Brown, B.S., P.E. McGraw-Hill Book Company, Incorporated, 330, West 42nd-street, New York 18, U.S.A. [Price 6 dollars]; and McGraw-Hill Publishing Company, Limited, Aldwych House, Aldwych, London, W.C.2. [Price 30*s.*]

The somewhat comprehensive objective of this book, in the words of the preface, is "to provide a complete, practical, working text-book and handbook suitable for study by any interested person and especially desirable for those who are working or have worked in design, installation, or operation of heating, ventilating, and allied mechanical equipment of buildings." It follows a pattern not unusual in American technical literature, in that it assumes no previous knowledge whatever of the subject on the part of the reader. The purchaser of a British work on air conditioning would not expect to find a chapter on the use of graphs, or explanations of the simpler properties of fractions or equations, but about a quarter of the 544 pages of text in this book are devoted to elementary physics and mathematics. The book has developed, in fact, from a course in air conditioning conducted by the Delehanty Institute of New York, and its lecture-room origin is very evident in its conversational style. The reader is led, by very easy stages, a considerable way into the field of air conditioning, every point being explained with assiduous care. The authentic voice of New York is perhaps heard on page 243, where a design problem is presented for a new Broadway "night spot" to be known as the "Glorioso Casino," with an "Orchid Room" and a "Glitter Room." In the latter, it is stated, there will be five "bartenders very busy," and 200 "patrons as active as officer workers, including those seated at bar." This last statement is presumably a printer's error and implies no reflection on the gallant forces of our great Ally; it is, perhaps, the only cryptic phrase in a very clearly written book.

The principles of air conditioning are admirably expounded and illustrated, and the introduction to psychometry, and the examples given of psychrometric charts, are really excellent. A large-scale Bulkeley chart is contained in a pocket at the back of the book. Most of the technical data are taken, by permission, from the standard publications of the American Society of Heating and Ventilating Engineers and the American Society of Refrigeration Engineers. This information is authoritative, but requires some modification for application to British

conditions; examples are the figures for the sensible and latent components of metabolic heat, and for solar radiation in heat gain. It is rather disappointing that there should be no reference to the reverse refrigeration cycle, particularly as the heat pump for warming during the winter months is making great headway in America. In any subsequent edition also, the opportunity might be taken to render the book rather more concise; at present, there is some repetition. As an example, Table 1 on page 227 is largely repeated in Table 2 on page 228, and these appear again, in identical form, as Tables 9 and 10 on pages 357 and 358. As it stands, however, the book may be regarded as an excellent course in air conditioning and cognate subjects.

Theory and Application of Mathieu Functions. By Dr. N. W. McLachlan. Oxford University Press (Geoffrey Cumberlege), Amen House, Warwick-square, London, E.C.4. [Price 42s. net.]

In engineering, the success which attends the trend from the simple to the more complicated structure or mechanism is attributable in no small measure to the way in which the dissolving power of mathematics has been utilised for the purpose of removing imperfections in the theory of yesterday so as to satisfy the practical and more exacting demands of to-day. Indeed, in essentials, the development of the mechanical sciences is due in many instances to the labours of some of the greatest mathematical analysts and geometers, whose results have facilitated the application of mathematics to the design of complex structures, and, in thermodynamics, to the study of the seeming chaos of molecular collisions, by means of the dynamical theory of gases. In the course of such applications frequent recourse is had to the principal equations of physics, any one of which, in the hands of a competent worker, can be used with advantage in the solution of certain important types of problem.

The subject-matter of the book under review is a case in point, since Mathieu's equation, which arose first in the study of the oscillations of an elliptic membrane, now occurs also in the oscillations of water in a lake having an elliptical boundary, in the motion of a pendulum on a vibrating support, and in certain generalisations concerning wave motion in a crystalline structure. Although the text is in two parts, theory and applications, the former occupying rather more than half the 400 pages of the volume, particular chapters in Parts I and II may be read together independently of the rest; as, for example, Chapters IV and XV, on the general theory and on applications to amplitude distortion in a moving-coil loud-speaker and allied problems, respectively. This is a great advantage in a work such as this, which has been prepared in the first place for technologists in general, for whom the order of relative importance of the 19 chapters may be arranged in various ways. For the student of applied mathematics a special value attaches to Mathieu's equation, because it is the simplest second-order equation with a periodic coefficient. Starting with a chapter on functions of integral order, in Part I, the author expounds the fundamental theory in a style which should appeal to the mathematically-minded engineer or physicist. The numerical solution of equations, Hill's equation, solutions in series of Bessel functions and in Bessel-function product series, as well as the wave equation in elliptic co-ordinates, deservedly receive detailed treatment. In this informative discussion of the theory there does not seem to be a single chapter which does not justify its place as regards both arrangement and content. This enables Dr. McLachlan to cover a wide range of topics in Part II, including applications to vibrational systems, electrical and thermal diffusion, electromagnetic waveguides, and the diffraction of sound and electromagnetic waves.

A considerable amount of original work by the author has clearly gone into his book, from the historical introduction to the selection of the numerous worked examples, many of which are novel. In addition, appendices dealing with the degeneration of the various Mathieu functions to Bessel functions of equal order, characteristic numbers, and bibliographical references to more than 200 papers and books have been included.

PLANCK'S CONTRIBUTION TO PHYSICS.

By G. F. Herrenden Harker, M.A.

The main facts of Professor Max Planck's career were given on page 352, *ante*, and the purpose of this article is to sketch briefly his outstanding contribution to physics and some of the consequences that have followed from it.

The two great entities of the physical world are matter and radiation. The problems of the nature and structure of both are of fundamental importance and neither can be treated independently of the other. Towards the close of the Nineteenth Century, it was generally acknowledged that matter was essentially discrete in structure. Atoms had long been familiar and the electron had just been isolated. On the other hand, the concept of continuity appeared to be dominant in radiation. The wave theory of light, consolidated by Young and Fresnel in the early years of the century, had provided so convincing and accurate an interpretation of such a wide range of phenomena that the corpuscular theory was deemed to be finally discredited. The clue to what the wave motion precisely consisted of had been supplied in Maxwell's electromagnetic theory (1861-62), which linked so brilliantly the two fields of optics and electricity. It remained to inquire into the nature of the sources of light.

The obvious suggestion was that an elementary luminous source must be a vibrator of some kind, and it seemed plausible to assume that the recently discovered elementary particle of negative electricity—the electron—might fill the role. Lorentz, in fact, showed that an electron forming part of an atom was well adapted to serve alike as a generator and an absorber of electromagnetic radiation. Momentarily displaced by some agency from its equilibrium position, the bound electron would execute damped oscillations, emitting radiation of the requisite kind at a calculable rate. Flood-lit by a beam of monochromatic radiation of the appropriate frequency, the bound electron could enter into resonance and thus absorb and scatter the energy of the beam. Certain numerical agreements lent support to this contention and it only then remained to provide an acceptable theory of these binding forces. This was roughly the state of affairs at the end of the Nineteenth Century. Many of the facts of emission and absorption had still to be explained, but there was no reason to suppose that any essentially new concepts would be required to account for them. Authoritative opinion inclined to the belief that the era of major discoveries in physics was over. Nothing could have been farther from the truth.

Of the two most important physical theories to emerge since then, one, Planck's quantum theory, was devised to account for the observations on black-body radiation carried out between 1897 and 1899 by Lummer and Pringsheim; and the other, Einstein's relativity theory, was developed to explain the negative result of the Michelson-Morley experiment. Curiously enough, both these problems had been referred to in one of Kelvin's last lectures as "clouds" over the dynamical theory of heat and light. To him, at the time, they seemed dark; they were, in fact, big with promise. The recognition and clear formulation of an unresolved difficulty is the first step towards its solution, which thereafter waits upon the creatively inspired investigator. Planck brought to bear on the former problem an unrivalled physical insight, rooted in an artistic imagination disciplined by nearly 20 years of research work in thermodynamics.

A body at a given absolute temperature T emits energy in the form of radiation. This radiation is complex, being resolvable into a continuous spectrum in which each monochromatic radiation specified by the corresponding value of the wavelength λ has a certain intensity. In general, this intensity depends on λ and T as well as upon the particular radiating substance. Only in the case of a "black" body does it depend solely on λ and T. Since the black body implies the possibility of securing a perfect radiating surface, it is a purely theoretical concept. Kirchhoff (who had guided Planck in his early thermodynamic studies and who was Planck's predecessor in the chair of experimental physics at Berlin) pointed out, however, that, within a cavity having opaque walls and maintained at a constant temperature, the condition of "full" or black-body radiation is automatically established. Lummer and Wien were thus enabled to realise the practical equivalent of a black body by constructing a uniformly heated enclosure and piercing a small opening through one of its walls. The radiation emerging from this minute aperture can be regarded as effectively identical with that radiated from a black body at the temperature of the enclosure.

Measurements carried out upon the emergent radiation then enable the spectral intensity distribution to be plotted either against λ for a series of values of T, or against T for a series of values of λ. Curves of the former (isothermal) family pass through a maximum for a particular wavelength ($\lambda_{max.}$) and tend asymptotically to the abscissa axis for very small or very large values of λ. As T increases, the maximum ordinate increases proportionately to the fifth power of the absolute temperature, meanwhile shifting progressively towards the shorter wavelengths in such a way that the product $\lambda_{max.}$ T remains constant. These experimental findings accord with certain results deduced from thermodynamical reasoning, such as the Wien displacement law and the Stefan-Boltzmann law, that the total radiated intensity is proportional to T^4. Efforts made by the leading theoretical physicists of the day—Rayleigh, Lorentz, Jeans, and others—to derive a formula to fit the actual experimental curves achieved only partial success and invariably predicted, over some portion of the spectral range, intensities of an entirely different order from those measured.

It is patent now that a solution was unattainable on the basis of the classical postulates of thermodynamics and electrodynamics alone. Success only crowned Planck's long and arduous efforts when he took the revolutionary step of introducing an entirely new postulate. "In science, as elsewhere," as he himself said, "fortune favours the brave." His celebrated formula, published in 1900, gave the intensity radiated in the infinitesimal wavelength interval, extending from λ to $\lambda + d\lambda$, from a black body at an absolute temperature T, in the form

$$E_\lambda \, d\lambda = \frac{C_1}{\lambda^5} \frac{1}{\exp\left(\frac{C_2}{\lambda T}\right) - 1} d\lambda.$$

For small values of λ T, it reduces to a formula given by Wien that held good over the visible and ultra-violet portion of the spectrum, but failed completely in the infra-red portion. For large values of λT, it reduces to Rayleigh's formula, which agreed with the measurements in the infra-red region but disagreed drastically with those in the ultra-violet.

Now, according to the electromagnetic theory of radiation, as completed by the introduction of the electron, the cavity walls are populated with electrons bound to their respective atoms. These electrons will be bound in a variety of ways and subject to restoring forces of all magnitudes, so that in view of their number, every natural frequency of oscillation over a wide range will be represented among them. For simplicity, Planck assumed these electromagnetic oscillators to be linear and lightly damped, each being characterised by a natural frequency ν, and further supposed dynamical equilibrium to be set up between an oscillator of frequency ν and the black-body radiation of this same frequency ν at the prevailing temperature T. It was then possible to establish a relation between the mean energy of these oscillators and the specific intensity of the corresponding radiation. Planck, however, was forced to the conclusion that, if his harmonic oscillators really did radiate while and as they oscillated in the manner prescribed by the electromagnetic theory, and if the principle of equipartition of energy was applicable to such an assemblage, then the spectral distribution curve must of necessity be quite different from what is observed.

He decided eventually that the only way out of the difficulty lay in abandoning the principle of equipartition of energy and assuming that the emission and absorption of energy by an oscillator can only occur discontinuously in fixed and indivi-